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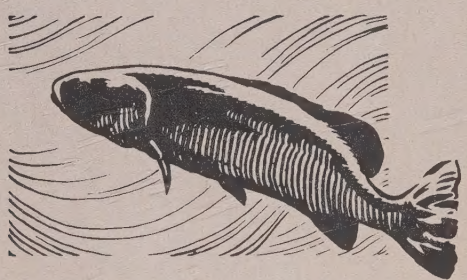

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DIETARY CALORIES AND THE PRODUCTION OF TROUT IN HATCHERIES

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Cortland, New York

DIETS FOR THE HUSBANDRIES OF HIGHER ANIMALS are compounded on the basis of the presence of the essential growth factors (vitamins and minerals) and an abundance of protein and energy to provide the raw materials for the production of flesh. If the growth essentials are present in the diet, the energy and the protein are varied to fill the needs of the stage in the life cycle of the animal. Protein and energy are the dietary factors--assuming the presence of the essential growth factors in the diet--that determine the efficiency of the diet and the growth rate of the animal.

Dietary energy is calculated in terms of calories. A calorie as used here is the amount of heat required to raise 1 gram of water 1° C. Diets are formulated on the total number of calories. For growth, both calories and protein must be available to the animal, and the ratio of the number of calories per 1 percent protein in the diet determines the efficiency of the diet as a growth promoter.

Calories in the diets of higher animals are calculated by using the values of 4 calories per gram of protein, 9 calories per gram of fat, and 4 calories per gram of carbohydrate. These calorie values take into account the digestibility of the various food groups. As digestibility is taken into account, the calculated dietary calories are actually available dietary calories. If this method of calorie calculation is applied to trout diets, the calorie values of 4, 9, and 4 cannot be applied, because trout differ from the higher animals in the ability to digest and absorb the various food groups.

The following values for the digestion of the food groups by trout were calculated from several sources:

	Percent	
Protein --	90	(Tunison et al. 1942; Wood[1/])
Fat ------	85	(McCay, Tunison, 1935)
Carbohydrate	40	(Phillips et al. 1948)

The digestive value for fat is a compromise value between the digestibility of hard and soft fats and the levels of hard and soft fats in trout diets. The digestive value for carbohydrate is based on the assumption that most of the carbohydrate in trout diets is in the form of starch. Foods which contain high levels of simple and compound sugars would have a higher value for the digestibility of the carbohydrate, and the value of 40 percent would not be valid. Neither Tunison (Tunison et al. 1942) nor Wood[1/] was able to show significant differences between the

[1/] Wood, E. M. Methods for protein studies with trout, with applications to four selected diets. Doctoral thesis, Cornell University, Ithaca, N. Y. 1952.

Mr. Brockway died on January 19, 1958.

digestibility of protein from all-meat diets and that from meat-dry meal mixtures. On this basis an average value of 90 percent was calculated for the digestion of protein by trout receiving the usual hatchery diets.

To determine the available calories in trout diets, the digestibility of the food groups is taken into consideration in the following manner:

5.65 (total calories per gram of protein) - 1.3 (calories per gram of protein present as nitrogen and unavailable for energy) x 0.90 (percent digestibility of protein by trout) = 3.9 calories available to trout per gram of protein.

9.45 (total calories per gram of fat) x 0.85 (percent digestibility of fat by trout) = 8.0 calories available to trout per gram of fat.

4.10 (total calories per gram of carbohydrate) x 0.40 (average percent digestibility of carbohydrate by trout) = 1.6 calories available to trout per gram of carbohydrate.

To estimate the number of calories required to produce a pound of trout, a number of diet experiments at the Cortland laboratory were recalculated in terms of calories. The calorie values used for these calculations were 3.9 calories per gram of protein, 8.0 calories per gram of fat, and 1.6 calories per gram of carbohydrate. The results of these calculations are summarized in table 1.

The first two diets listed in table 1 produce the same growth rates and similar conversions of food into fish flesh. The values in the table represent an average of 10 experiments over a 12-year period for the fresh meat diet and an average of 13 experiments over a similar period for the fresh meat-dry meal mixtures. The fresh meat diet contains 18.3 percent protein, and the fresh meat-dry meal diet 27.6 percent protein. As the growth rates and the conversions of food into flesh for the two diets are equal, it is possible to compare these diets on the basis of the number of calories required to produce a pound of fish.

Although the fresh meat diet contains just a little more than half of the calories in the fresh meat-dry meal mixture, the production of a pound of fish requires 1,204 calories with the fresh meat diet and 2,095 with the fresh meat-dry meal diet. This suggests that the fresh meat diet is far more efficient than the fresh meat-dry meal diet, even though the conversion factors obtained with the two diets are equal. It requires 359.6 grams of dietary protein to produce a pound of fish when the fresh meat-dry meal diet is fed, and 238.6 grams of protein when the fresh meat diet is fed. The utilization of protein for flesh production is more efficient with the fresh meat diet than with the fresh meat-dry meal mixtures.

The normally accepted level of protein in trout diets is 28 percent. Formerly, hatchery fish were raised more efficiently (in terms of both calories and grams of protein required to produce a pound of fish) on diets containing 18 percent protein.

Fresh meat-dry meal diets are high-calorie diets. A comparison of the mixtures (high-calorie diets) listed in table 1 shows that in all experiments approximately 2,000 calories (average, 2,096) and 350 grams of protein are required to produce a pound of trout. Basically similar ingredients are used in all of the diet mixtures. The calorie content of these diets ranges from 722 to 1,094 calories per pound of food. The conversion factor (food into fish flesh) decreases as the calorie content of the diet increases. A conversion of 2.0, which results from feeding pellets 6 days and fresh meat 1 day a week, is equivalent (in terms of calories required to produce a pound of fish) to a conversion of 2.9 that results from feeding a diet composed of fresh meat and dry meals. The use of calories to judge the efficiency of trout diets eliminates percentage values of the diet mixtures and places judgment on the actual number of grams of food consumed by the fish.

From the values in table 1 it is tentatively concluded that when high-calorie

TABLE 1.--A comparison of the total calories and grams of protein required to produce one pound of brook trout

Diet composition (percent)	Number of observations	Average total percent gain	Average total conversion	Percent protein in the diet	Total calories per pound of diet	Calories fed per pound of fish produced	Grams of protein fed per pound of fish produced	Calories per percent protein per pound of diet
Water temperature, 47° F.: 20-week experimental period[1]								
Pork melts 48 Beef liver 50 Salt 2	10	1,717	2.9	18.3	415.0	1,204	238.6	22.6
Pork melts 50 Dry meal[2] 50	13	1,854	2.9	27.6	722.3	2,095	359.6	26.2
Pork melts 30 Beef liver 20 Dry meal[2] 50	2	2,160	2.7	27.3	744.0	2,088	334.8	27.2
Water temperature varied with season (40° F. to 60° F.); 6-month period[3]								
Beef melts 32 Beef liver 16 Dry meal[4] 52	2	562	2.9	27.4	744.5	2,158	357.6	27.2
Pellets, 5 days weekly Meat mixture, 2 days weekly[5]	2	634	2.1	35.3	930.7	1,954	333.5	26.6
Pellets, 6 days weekly Meat mixture, 1 day weekly[5]	2	535	2.0	40.6	1,094.1	2,188	363.8	27.0
Average of diets containing dry meals----------	--	-----	---	----	-------	2,096	349.8	26.8

[1] Average weight of fish at start, 0.5 to 0.8 gram.
[2] Equal parts of cottonseed meal, wheat midds, dried skim milk, fish meal, and 4 percent salt.
[3] Average weight of fish at start, approximately 12 grams.
[4] Equal parts of cottonseed meal, red dog flour, fish meal, distiller's solubles, and 4 percent salt.
[5] Standard Cortland pellet (Phillips et al. 1953); meat mixture: 49 percent beef spleen, 49 percent beef liver, and 2 percent salt.

diets similar to those listed in the table are fed to hatchery trout, the requirement to be expected is approximately 2,100 calories and 350 grams of protein for each pound of fish produced. If these values are used, a diet composed of 100 percent Cortland pellets (containing 1,252 calories per pound) should produce trout at a conversion rate of 1.68 pounds of food per pound of fish produced. Table 2 shows that such a diet over a 12-month period produced fish at a conversion rate of 1.75 pounds, a difference of only 0.07 pound of food per pound of fish produced.

If this method of calculation is applied to the high-calorie diets listed in table 1, the calculated and observed food conversions are:

Diet composition		Conversion	
		Calculated	Observed
Pork melts	50	2.9	2.9
Dry meal	50		
Pork melts	30	2.8	2.7
Beef liver	20		
Dry meal	50		
Beef melts	32	2.8	2.9
Beef liver	16		
Dry meal	52		
Pellets, 5 days weekly Meat, 2 days weekly		2.2	2.1
Pellets, 6 days weekly Meat, 1 day weekly		1.9	2.0

Although the observed food conversions generally are based on few experiments, the consistency of agreement between the observed and calculated conversion values lends support to the observation that when high-calorie diets similar to those listed in table 1 are fed to trout, 2,100 calories and 350 grams of protein are required to produce a pound of trout.

The results listed in table 3 indicate that the values of 2,100 calories and 350 grams of protein per pound of fish produced are valid only when high-calorie diets similar to those listed in table 1 are fed to hatchery trout. In table 3 hatchery foods are compared with natural foods. The number of calories required to produce a pound of trout ranges from 2,095 (fresh meat-dry meal mixture) to 910 (living brine shrimp). The amount of protein required per pound of fish produced ranges from 359 grams to 143 grams.

The goal of experiments on diets for hatchery trout should be to compound diets that will reduce the calories and protein required to produce a pound of fish. That such reduction is possible is shown through feeding diets composed of fresh meat or natural foods, as both of these diets produce trout more efficiently (in terms of calories and protein) than the commonly used hatchery diets. Neither natural food nor meat diets are practical in production hatcheries. The problem is to improve the fresh meat-dry meal mixtures and the pellet diets so that the results from feeding these in trout hatcheries are equal to the results obtained by feeding the more efficient trout foods.

At least three factors are to be considered in any attempt to reduce the calorie and protein intake of hatchery fish. First, the ratio of calories to percentage of protein in the diet is an important consideration. This ratio ranges from 22.6 (all fresh meat diets) to 27 (fresh meat-dry meal diets), and from 24 to 28 in natural foods. In chick nutrition, the calorie-protein ratio ranges from 35 to 53, depending on the stage in the life cycle of the chick. Fish diets contain more protein in relation to calories than do chick diets. Second, diet efficiency may be improved through protein-quality studies. Protein of poor quality will be used for energy or deposited in the body as fat. At present, no measure of protein quality in trout nutrition is available. Such studies must be undertaken if truly efficient trout diets are to be developed. Third, the basic nutritional requirements of trout must be understood so that the requirements may be satisfied in the base diet before the calories and protein are altered.

The values established for the calorie and protein requirements of trout are not firm values. They are average values based on a number of experiments. These values will be improved as diets are improved or as diet mixtures are altered.

TABLE 2.--A comparison of the total calories and grams of protein required to produce one pound of brown trout

Diet fed	Number of observations	Average total percent gain	Average total conversion	Percent protein in the diet	Total calories per pound of diet	Calories fed per pound of fish produced	Grams of protein fed per pound of fish produced	Calories per percent protein per pound of diet
Water temperature varied with season (47° F. to 60° F.); 1-year period[1]								
Pellets, 5 days weekly Meat mixture, 2 days [2]	2	863	2.15	35.3	930.7	2,001	341.4	26.6
Pellets, 7 days weekly No meat [2]	2	950	1.75	44.3	1,253.7	2,192	348.3	28.3

[1] Average weight of fish at start, 12 grams.

[2] Standard Cortland pellets (Phillips et al. 1953); meat mixture, when fed: 49 percent beef spleen, 49 percent beef liver, 2 percent salt.

TABLE 3.--A comparison of the total calories and grams of protein required to produce one pound of brook trout fed two hatchery diets and natural food

Diet fed	Number of observations	Average total percent gain	Average total conversion	Percent protein in the diet	Total calories per pound of diet	Calories fed per pound of fish produced	Grams of protein fed per pound of fish produced	Calories per percent protein per pound of diet
			Water temperature, 47° F.					
Pork melts 50 Dry meal 50 1/	13	1,854	2.9	27.6	722.3	2,095	359.6	26.2
Pork melts 48 Beef liver 50 Salt 2 2/	10	1,717	2.9	18.3	415.0	1,204	238.6	22.6
Natural food 3/	2	335	2.7	11.8	336.4	910	143.1	28.4
Natural food 4/	calculated values		4.9	11.5	280.8	1,372	238.8	24.4

1/ Average weight of fish at start, 0.5 to 0.8 gram. Dry meal: equal parts of cottonseed meal, wheat midds, dried skim milk, fish meal, and 4 parts salt. 20-week experimental period.
2/ Average weight of fish at start, 0.5 to 0.8 gram. 20-week experimental period.
3/ Average weight of fish at start, 0.058 gram. 5-week experimental period. Fish fed living brine shrimp.
4/ Calculated from average literature values for analyses and conversion of natural food into fish flesh.

One piece of evidence that evolved while the data in terms of calories were being calculated is the apparent lack of effect of water temperature on the number of calories required to produce a pound of fish (table 1). When trout are fed the diets that are listed in table 1 (high-calorie diets), approximately the same number of calories is required to produce a pound of trout in warm water as in colder water. This indicates that increased food intake is used for growth and maintenance at the same ratio per pound of food, regardless of the water temperature.

The trout used in the experiments listed in table 1 were brook trout. The experiments listed in table 2 were conducted with brown trout. The data show that species of trout has no effect on the number of calories or grams of protein required to produce a pound of fish.

The data in table 1 suggest that the size of the fish does not alter either the calorie or the protein requirement per pound of fish produced. The fish held in the colder water were much smaller than those held in the warmer water. The calories and protein per pound of fish produced are similar at either water temperature, even though there is a difference in fish size.

If future experiments confirm that water temperature, fish size, and species do not affect the basic requirement for calories and protein per pound of fish produced, it will be possible to predict results from many different combinations of diet mixtures, provided that the commonly used fish foods are used in the diets. Fish-culturists, unknowingly in most cases, have taken into account the calorie content of trout diets when establishing the levels of food to feed. Thus, when pellets are fed to trout, 60 percent of the values shown in the feeding tables for trout (Deuel et al. 1952) are used to calculate the pounds of pellets to be used. Sixty percent of 1,252 (calories per pound of pellets) equals 751 calories fed to the trout. This compares favorably with 722 calories per pound of fresh meat-dry meal mixtures, fed at 100 percent of the values given in the feeding tables for trout.

Experimental Effect of Dietary Protein and Calories on the Growth and Body Chemistry of Brook Trout

Previous work at Cortland postulated that natural fish foods were more efficient than hatchery diets in rearing trout (Phillips et al. 1956, 1957). The protein content of modern hatchery diets is high in comparison with that of diets used in other fields of animal husbandry. Trout are poor utilizers of carbohydrate (Phillips et al. 1948). High levels of dietary fat may have undesirable effects on fish (Phillips et al. 1949, 1950). It logically appears from these previous experiments that hatchery trout require high-level protein diets. However, natural foods contain 11.5 percent protein, and trout in hatcheries have been reared satisfactorily on low-level protein diets (fresh meat containing 18 percent protein). Recently suggested hatchery diets composed of dry meals or fresh meat-dry meal mixtures contain from 25 to 45 percent protein. Diets that contain high levels of protein are expensive. In a series of experiments run during the summer of 1957, attempts were made to reduce the protein intake of hatchery trout by varying the level of both protein and calories in the diet.

Method

The experiments were conducted over a 20-week period with brook trout held in troughs supplied with water at an average temperature of 51° F.

The presence of the dietary growth-promoting essentials was assured by feeding to all experimental groups of fish a base diet composed of 30 percent each of beef liver and beef spleen; 9.5 percent each of cottonseed meal, distiller's solubles, fish meal, and red dog flour; and 2 percent salt.

The control groups of fish received the base diet at the suggested level in the standard feeding tables for trout (Deuel et al. 1952). The dietary protein level was altered by reducing the food allowance by 25 percent, and the number of calories received by the fish was varied by reducing

the food allowance and/or by adding corn oil to the diet. Corn oil contains almost none of the growth essentials; therefore, addition of oil to the diet only increased the calorie intake of the fish.

In those experiments in which the level of the base diet fed was reduced, the weight of the food fed was brought to the weight of food fed to the control groups by the addition of water to the diet mixture. A mixture of 75 percent of the base diet and 25 percent water disintegrated readily when placed in the water of the experimental troughs. To control disintegration of the food, 4 percent medium-viscosity CMC (cellulose gum) was added to some of the diets in lieu of water. The addition of CMC (Wood, Griffin, and Snieszko, 1954) formed a food mixture that resisted disintegration when the food was placed in water and thus assured almost complete consumption of the food. Each of the experimental diets was fed to duplicate troughs of fish. The diets employed in these experiments are listed in table 4.

At the end of the experimental period, samples of fish were removed from the experimental groups and their bodies analyzed for major components. Water was determined by drying in a vacuum oven; protein, by a modified Hengar method (Morgan, Lackey, and Gilcreas, 1957); fat, by continuous ether extraction; and ash, by ignition (to constant weight) in a muffle furnace.

Growth data and data from the chemical analyses of the bodies were calculated in terms of calories in the diet and calories produced in the bodies. The values used for these calculations (3.9 calories per gram of protein, 8.0 per gram of fat, and 1.6 per gram of carbohydrate) are described elsewhere in this report.

The growth data are listed in table 4, the data from the chemical analyses in table 5, and the calculations of the growth and chemical data in terms of calories in table 6.

Discussion

Growth data.--Fish fed the control diet (table 4) grow at a faster rate than any of the other experimental groups. Trout that receive the diets containing the base diet at a reduced feeding level and water grow at a much slower rate and show a much less efficient conversion of food into flesh than the fish receiving the control diet. The addition of CMC to the control diet reduces the growth rate. Wood, Griffin, and Snieszko (1954) reported that CMC produced only a slight effect on the growth rate. The growth rate of the fish on a diet composed of 75 percent base diet, 21 percent water and 4 percent CMC is equal to the growth rate of the fish on the base diet and CMC. Although actual intake of the base diet is decreased by 25 percent, the growth rate is not reduced.

The addition of corn oil to the diets containing CMC (control diet and CMC, and the reduced-level diet plus water plus CMC) apparently increases the growth rate of both experimental groups. This apparent increase in growth rate is actually caused by increased fat deposition within the bodies. (See discussion of the chemical data.)

In these experiments 25 percent of the diet may be replaced with water and CMC without harming either growth or conversion rates as compared with the growth and conversion rates of trout fed the control diet containing CMC. The replacement of 25 percent of the base diet with only water decreases the growth rate and causes a less efficient conversion of food into flesh than is produced by feeding the control diet. These studies suggest the possibility of reducing the protein intake without harmful effects on the growth or conversion rates.

Chemical data.--There is no difference in the deposited protein in any of the experimental groups except the groups that received the reduced levels of the base diet with added water but no CMC (table 5). The deposition of ash does not vary with the diet fed. There is a difference in the fat content of the bodies of the various groups. In the bodies of those fish which received corn oil, there is a significant increase in the fat content. The additional fat is deposited at the expense of body water, as there is a decrease in water

TABLE 4.--Summary of the effects of dietary calories and protein on the growth rate of brook trout

[Except for the 6th diet listed, all values pertaining to growth are averages of duplicate experiments. The values for the 6th diet are for a single experiment, as the replicate was lost during the experimental period.]

Diet composition[1] (percent)		Calories per pound of diet	Percent protein in the diet	Average weight of fish at end (grams)[2]	Total percent gain	Total conversion	Average mortality per 2-week period
Beef liver	30						
Beef spleen	30						
Dry meal	40	653	25.7	46.5	4,159	2.5	0.02
Beef liver	22.5						
Beef spleen	22.5						
Dry meal	30						
Water	25	486	19.3	21.9	1,890	3.3	0.04
Beef liver	28.8						
Beef spleen	28.8						
Dry meal	38.4						
CMC binder	4	625	24.7	30.5	2,672	2.8	0.05
Beef liver	22.5						
Beef spleen	22.5						
Dry meal	30						
Water	21						
CMC binder	4	486	19.3	29.2	2,555	2.9	0.14
Beef liver	27						
Beef spleen	27						
Dry meal	36						
CMC binder	4						
Corn oil	6	801	23.1	44.6	3,955	2.5	0.04
Beef liver	21.15						
Beef spleen	21.15						
Dry meal	28.2						
CMC binder	4						
Corn oil	4.5						
Water	21	621	18.1	36.0	3,173	2.6	0.01
Beef liver	21.15						
Beef spleen	21.15						
Dry meal	28.2						
Corn oil	4.5						
Water	25	621	18.1	21.8	1,879	3.1	0.07

[1] Dry meal: equal parts cottonseed meal, red dog flour, fish meal, distiller's solubles, and 4 percent salt.

[2] Average weight of fish at start, 1.1 grams.

TABLE 5.--Analyses of the bodies of trout used in experiments on the effect of dietary calories and protein on growth rate of brook trout

Diet composition (percent)		Percent			
		Water	Ash	Protein	Fat
Beef liver	30				
Beef spleen	30				
Dry meal	40	75.9	2.0	15.7	5.5
Beef liver	22.5				
Beef spleen	22.5				
Dry meal	30				
Water	25	77.9	2.0	14.1	4.7
Beef liver	28.8				
Beef spleen	28.8				
Dry meal	38.4				
CMC binder	4	75.4	2.2	15.5	5.8
Beef liver	22.5				
Beef spleen	22.5				
Dry meal	30				
Water	21				
CMC binder	4	76.0	2.0	15.7	5.6
Beef liver	27				
Beef spleen	27				
Dry meal	36				
Corn oil	6				
CMC binder	4	73.7	2.1	15.3	8.4
Beef liver	21.15				
Beef spleen	21.15				
Dry meal	28.2				
Water	21				
Corn oil	4.5				
CMC binder	4.0	72.0	2.0	15.3	10.4
Beef liver	21.15				
Beef spleen	21.15				
Dry meal	28.2				
Water	25				
Corn oil	4.5	75.0	2.2	15.1	6.5

content but no change in the protein or ash content. The addition of corn oil to the diet does not increase the growth rate (table 4) but rather increases the total weight by additional fat deposition (table 5).

Calorie data.--Growth and chemical data (in calories) are shown in table 6. The number of calories required to produce 1 pound of fish ranges from 1,409 to 2,002. The number of calories required to produce a pound of fish in these studies is lower than the number of calories established for fish production with the high-calorie diets described earlier in this report. The numbers of calories per pound of diet fed are lower in the present experiments than in those previously discussed, with the exception of the control diet containing CMC and corn oil. The latter diet contains 801 calories per pound of food, and it required 2,002 calories to produce a pound of fish; whereas the previously described high-calorie diets (722 and more calories per pound) required 2,100 calories. As only the high-calorie diet of the present experiment (801 calories per pound) required a number of calories similar to that required in the previously described experiments to produce a pound of fish, it is possible that the lower calorie content of the diets in the present series of experiments is responsible for the more efficient fish production (in terms of calories per pound of fish produced). The present experiments lend credence to the previous discussion of calories, as it is possible to decrease the calories required to produce a pound of fish by altering the diet.

In the present experiments the fresh-meat level is 60 percent of the base diet, whereas in the previously discussed experiments the fresh-meat level does not exceed 50 percent of the diet (table 1). Perhaps the ratio of fresh meat to dry meal in the diet accounts in part for the production of fish, in the present experiments, below the postulated 2,100 calories required per pound of fish produced.

The calories deposited as protein in the fish body are constant throughout the experiments, with the exception of the fish on a diet composed of 75 percent base diet, 25 percent water, but no CMC binder.

TABLE 6.--Comparison of the total intake of calories and the deposition of calories within fish used in the experiments on the effect of dietary calories and protein on the growth rate of brook trout

Diet composition	Calories per pound of diet	Total conversion	Calories required per pound of fish produced	Calories deposited as protein per pound of fish produced	Calories deposited as fat per pound of fish produced	Total calories deposited per pound of fish produced	Calories used for energy per pound of fish produced
Beef liver 30 Beef spleen 30 Dry meal 40	653	2.5	1,632	279	200	479	1,153
Beef liver 22.5 Beef spleen 22.5 Dry meal 30 Water 25	486	3.3	1,603	249	171	420	1,183
Beef liver 28.8 Beef spleen 28.8 Dry meal 38.4 CMC binder 4	625	2.8	1,750	274	211	485	1,265
Beef liver 22.5 Beef spleen 22.5 Dry meal 30 Water 21 CMC binder 4	486	2.9	1,409	279	203	482	927
Beef liver 27 Beef spleen 27 Dry meal 36 CMC binder 4 Corn oil 6	801	2.5	2,002	270	305	575	1,427
Beef liver 21.15 Beef spleen 21.15 Dry meal 28.2 CMC binder 4 Corn oil 4.5 Water 21	621	2.6	1,619	270	377	647	972
Beef liver 21.15 Beef spleen 21.15 Dry meal 28.2 Corn oil 4.5 Water 25	621	3.1	1,925	267	235	502	1,423

The calories deposited as fat vary with the diet. The fish that are fed corn oil in the diet produce more calories in the form of fat than do those fed the diet lacking corn oil. The fish which do not receive corn oil in the diet deposit a relatively constant level of calories in the form of fat.

The total number of calories deposited in the fish body is constant for all diets except those containing corn oil. The addition of corn oil to the diet increases

the deposition of calories. This increase is in the form of fat calories only, as there is no increase in the deposition of protein calories when corn oil is fed. This supports the contention that corn oil in the diet does not increase the actual growth but increases the weight through additional fat deposits in the body.

The difference between the calories required to produce a pound of fish and the calories deposited in the body is used to estimate the number of calories required for energy. This estimation is relatively sound, as differences in digestibility of the food groups (which would invalidate conclusions) are taken into account in the values used for calculating calories in both the foods and the bodies (previous section of this report).

There are differences in the calories required for energy by the fish fed the various diets. All fish fed diets in the amounts equal to the values in the standard feeding tables (Deuel et al. 1952) require more energy than do the fish fed reduced levels. This suggests that a full allowance of food, which contains a high level of protein (25 percent and over), increases the metabolic rate of the fish.

High-protein diets increase the metabolism of the bodies of higher animals. If the protein intake of the animal exceeds the need for protein, the excess is either burned for energy or deposited as fat. The use of protein for other than protein purposes increases the metabolic rate (and therefore the energy required) to eliminate the toxic products of protein catabolism. This effect is demonstrated in the present experiments by comparing those in which corn oil is added or omitted. The calories required for energy are the same with either diet; but when corn oil is added, the dietary oil is deposited as fat and is not used for energy--at least not completely. Additional dietary calories do not increase the need for energy if the additional calories are added to the diet as fat. The 75-percent base diet, with added water, CMC, and corn oil, contains approximately the same number of calories per pound of food as the control diet plus CMC; but the fish require only 972 calories for energy from the former and 1,183 calories for energy from the latter. The latter diet contains more calories in the form of protein. This lends support to the contention that if the calorie content of the diet is increased by protein, the energy requirement of the fish increases.

The food protein required to produce a pound of fish is 288 grams when full allowances of diets containing CMC are fed (conversion x 454 x percent protein in the diet), and 233 grams when the trout are fed the reduced levels of food with added water and CMC. Because the percentage of protein in the bodies of these two groups is the same (table 5), the difference of 55 grams of required food protein per pound of fish produced must have been utilized for energy.

Earlier in this report it is noted that when high-calorie diets are fed to trout, 350 grams of protein are required per pound of fish produced. Both the protein and the calorie content of the diet are lower in the present experiments than in the earlier experiments. As shown in the present experiments, the level of dietary protein required to produce a pound of fish can be reduced by altering the diet.

The calculations of growth data and diet composition in terms of calories present the data in terms of the actual food ingested and in terms of the actual production of flesh. These calculations, based on the actual grams of food (or calories) consumed and used by the fish, eliminate the use of percentage values (or rates). Such calculations eliminate the necessity for additional calculations of percentages on a dry basis, and the conversion factor actually becomes the calories required per pound of fish produced and not the pounds of food (wet or dry basis) required to produce a pound of trout. The conversion factor, when expressed in terms of calories, provides a true picture of the utilization of food.

General.--These experiments suggest, as previously postulated (Phillips et al. 1956, 1957), the possibility of reducing the protein intake of hatchery trout without sacrificing either the growth rate or the

conversion factor. High-protein diets increase the metabolic rate, and many of the dietary calories are used as energy and are unavailable for growth. Reducing the level of the dietary protein (which apparently exceeds the protein needs of the fish in our present hatchery diets) reduces the amount of food used for energy (reduces protein catabolism) and thus makes more of the absorbed food available for the production of body tissues. Tunison and coworkers (1944) pointed out that apparently trout use a portion of the dietary protein for energy. Because trout are poor users of carbohydrate and high-fat diets may be undesirable, some of the dietary protein must be used for energy. It is important to establish the protein energy needs of the trout and to design diets that will not provide more protein than is needed.

To reduce the food intake by 25 percent and replace the removed food with water appears unreasonable. The growth and conversion rates of the fish receiving the full food allowance (table 4) are similar to those of the fish receiving the reduced food level. The number of calories required to produce a pound of fish is less when the fish are fed the reduced food level than when they are fed the full food allowance. The calculations (table 6) of the use of dietary calories in the body remove the apparent unreasonableness of these experiments. Those fish given the reduced food level received 25 percent of the diet as non-growth-promoting material (water). Those fish receiving the full food allowance increased their energy requirement by about 25 percent (1,265 calories for energy per pound of fish produced versus 927 calories required for energy per pound of fish produced). In both experiments about 25 percent of the diet was unavailable for growth, and hence the conversion factors are similar.

In these experiments CMC reduces the growth rate of the fish. Comparison of these experiments must be limited to those in which the fish are fed diets containing CMC. However, the calories required for energy are of the same magnitude in those fish which received either the base diet or the base diet and CMC.

These experiments add validity to the contention that it is possible to reduce the protein level of hatchery foods and to control and estimate trout growth by regulating dietary calories. The control of total diet calories and the form in which the diet calories are fed should result in more efficient hatchery diets. With increased knowledge of the basic nutritional requirement of fish, including protein-quality studies, hatchery diets should approach the postulated efficiency of natural fish foods.

Literature Cited

Deuel, C. R., D. C. Haskell, D. R. Brockway, and O. R. Kingsbury
1952. The New York State fish hatchery feeding chart. N. Y. Cons. Dept., Fish. Res. Bull. 3, 59 pp. Third edition.

McCay, C. M., and A. V. Tunison
1935. Report of the experimental work at the Cortland Hatchery for the year 1934. N. Y. Cons. Dept., 17 pp., illus. J. B. Lyon Co., Albany.

Morgan, G. B., J. B. Lackey, and F. W. Gilcreas
1957. Quantitative determination of organic nitrogen in water, sewage, and industrial wastes. Anal. Chem. 29 (5): 833-835.

Phillips, A. M., Jr., A. V. Tunison, and D. R. Brockway
1948. The utilization of carbohydrates by trout. N. Y. Cons. Dept., Fish. Res. Bull. 11, 44 pp., illus.

------ D. R. Brockway, Maurice Bryant, E. O. Rodgers, and J. M. Maxwell
1949. The nutrition of trout. Cortland Hatchery Rept. 18. N. Y. Cons. Dept., Fish. Res. Bull. 13, 30 pp., illus.

Phillips, A. M., Jr., D. R. Brockway, A. J. J. Kolb, and J. M. Maxwell
1950. The nutrition of trout. Cortland Hatchery Rept. 19. N. Y. Cons. Dept., Fish. Res. Bull. 14, 24 pp., illus.

------ F. E. Lovelace, D. R. Brockway, and G. C. Balzer, Jr.
1953. The nutrition of trout. Cortland Hatchery Rept. 22. N. Y. Cons. Dept., Fish. Res. Bull. 17, 31 pp., illus.

------ F. E. Lovelace, H. A. Podoliak, D. R. Brockway, and G. C. Balzer, Jr.
1956. The nutrition of trout. Cortland Hatchery Rept. 24. N. Y. Cons. Dept., Fish. Res. Bull. 19, 56 pp., illus.

------ H. A. Podoliak, D. R. Brockway, and G. C. Balzer, Jr.
1957. The nutrition of trout. Cortland Hatchery Rept. 25. N. Y. Cons. Dept., Fish. Res. Bull. 20, 61 pp., illus.

Tunison, A. V., D. R. Brockway, J. M. Maxwell, A. L. Dorr, and C. M. McCay
1942. The nutrition of trout. Cortland Hatchery Rept. 11. N. Y. Cons. Dept., Fish. Res. Bull. 4, 52 pp., illus.

------ A. M. Phillips, H. B. Shaffer, J. M. Maxwell, D. R. Brockway, and C. M. McCay
1944. The nutrition of trout. Cortland Hatchery Rept. 13. N. Y. Cons. Dept., Fish. Res. Bull. 6, 21 pp., illus.

Wood, E. M., P. J. Griffin, and S. F. Snieszko
1954. Synthetic binding of trout diets. Prog. Fish-Cult. 16 (1): 19-24.

PLASTIC BAGS FOR TRANSPORT OF TROUT IN SOUTH AFRICA

The Jonkershoek Hatchery at Stellenbosch, Cape of Good Hope, in the Union of South Africa, has reported two successful experiments with plastic bags and oxygen as a means of transporting trout fry and fingerlings.

For transportation by air, 1,000 rainbow and 100 brown trout fry were placed at 10:30 a.m. in 8 polythene bags (8 by 12 inches) with oxygen and 2 pounds of water in each. The bags were packed in 2 cardboard containers with woodshavings as insulation. Because the departure of the plane was delayed by bad weather, the fish were not delivered at their destination until 4:30 p.m. the following day. Although this operation involved 30 hours' travel, all but 3 percent of these trout fry survived.

A particular section of a river in the Province had not been stocked previously because the operation involved the movement of fish up a steep climb of about an hour's duration--a task that would have been most difficult with the conventional containers. To stock these waters, polythene bags were tried as being less difficult to carry. For this project, 1,000 brown and rainbow trout fingerlings were taken as close to the area as possible in the hatchery's 80-gallon insulated tank. They were then transferred to 15 polythene bags (8 by 12 inches) with oxygen and water. The bags of fish were placed in cardboard containers, and one or two of these were carried in a rucksack by one man. All the fingerlings survived the trip.

SURVIVAL AND RETENTION OF TAGS, AND GROWTH OF TAGGED LAKE TROUT IN A REARING POND

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THE U. S. FISH AND WILDLIFE SERVICE AND OTHER AGENCIES represented on the Upper Great Lakes Fishery Committee[1] are currently conducting marking experiments in Lake Superior to determine the proper size of lake trout at planting and whether survival or growth may be increased by holding lake trout in rearing stations beyond their first summer. As part of this study, 2-summer-old lake trout were tagged and released in four localities in Lake Superior in October 1955, May and October 1956, and May 1957 to supplement earlier (1952-55) plantings of fin-clipped fingerlings and yearling fish (planted in fall and spring, respectively).

In October 1955 an experiment was begun at the Pendills Creek (Michigan) Fish-Cultural Station of the Service to assist in the evaluation of returns from lake trout tagged with different types of tags and stocked in Lake Superior. It was hoped that this study would also aid in the appraisal of earlier (1950-54) tagging experiments with larger native Lake Superior lake trout, and that it might suggest a satisfactory method for marking brood lake trout in hatcheries for studies of individual differences in egg production and dates and periodicity of spawning.

Materials and Methods

Lots of 100 each of 2-summer-old lake trout (average length, 8.5 inches), which were marked with different types of tags on October 5-11, 1955, were held in a rearing pond for 1 year. A control group of 100 fish were marked by removal of the adipose fin. Shetter's (1951) observations on mortality and growth of fin-clipped fingerlings justified the assumption that the removal of this tiny fin would have no significant effect on survival or growth. The surviving marked fish of all lots were measured and weighed on May 18 and October 10, 1956, about 7 and 12 months, respectively, after the beginning of the experiment. All fish were returned to the pond after the May 18 observations, including those which had lost their marks by that time. Fish that died or lost their tags were combined in forming judgment as to the effectiveness of each mark.[2]

[1] The Upper Great Lakes Fishery Committee, which meets annually in conjunction with the Midwest Wildlife Conference, is presently composed of representatives from each of the States bordering the three upper Great Lakes, the Province of Ontario, the Canadian Department of Fisheries, and the U. S. Fish and Wildlife Service.

[2] Only 9 dead fish were found during the experiment; thus most of the decreases observed in the numbers of marked fish were probably due to lost tags rather than to mortality.

Dr. Eschmeyer was formerly associated with the Great Lakes Fishery Investigations of the U. S. Fish and Wildlife Service.

The tags used were: Petersen (attached below the dorsal fin); cheek (Cable 1950); No. 3 monel strap tag on the lower jaw (Shetter 1936); No. 3 strap tag on the upper jaw; and the streamer tag, applied near the origin of the dorsal fin, according to the technique suggested by Joeris (1953). Two lots of fish were marked with streamer tags--one with the tags attached with No. 34 Nylock nylon gill net twine (tensile strength, 4.5 pounds), and the second with tags attached with No. 46 twine (tensile strength, 6 pounds). Fish marked with streamer tags were held in a separate section of the raceway (but otherwise under closely comparable conditions) because of the tendency of the threads of the streamer tags to become entangled with projecting portions of the other types of tags.

George A. Drake, Superintendent of the Pendills Creek Station, cared for the fish during the experiment. Leonard S. Joeris supervised the field work in May and October 1956. Howard J. Buettner assisted in the tabulation of data. Don W. Hayne made suggestions for the analysis of the data.

Survival and Retention of Marks of Tagged and Fin-Clipped Lake Trout

Comments on the survival and retention of marks of lake trout tagged with different types of tags are based on the data of table 1.

By May 1956, all tags had been lost from fish marked with upper-jaw tags. The lake trout used in this experiment obviously were too small to retain No. 3 strap tags attached at this site. Results with streamer tags also were poor; though 19 percent (data for 2 twine sizes combined) remained in place at the end of 7 months, only 1 of 200 streamer tags remained intact at the end of 1 year.[3/]

TABLE 1.--Numbers of lake trout marked in October 1955 which retained their marks in May and October 1956

Type of tag	Number of marked fish present		
	October 1955	May 1956	October 1956
Petersen	100	96	86
Cheek	100	93	85
Jaw			
Lower	100	96	91
Upper	100	0	0
Streamer			
No. 34 thread	100	23	1
No. 46 thread	100	15	0
Adipose fin clip	100	1/ 91	95

1/ Four or more fish apparently were overlooked in May 1956.

The following percentages of fish identified by the other types of marks were recovered at the end of the experiment: Petersen, 86; cheek, 85; lower-jaw, 91; and fin clip, 95. The difference in rate of survival or retention of the mark among these 4 lots of marked fish was not significant.

The relative rates of survival or retention of different types of tags by juvenile lake trout held at a rearing station were dissimilar from the rates of recovery (based on voluntary returns by commercial and sport fishermen) when these same types of tags were applied to larger (average total length, 19.7 inches) native lake trout in Lake Superior (table 2). In contrast to the poor results obtained with streamers in the rearing pond, 29.1 percent of 398 Lake Superior fish marked with streamer tags (No. 34 thread) in 1952-54 were later recaptured. This rate of recovery was significantly better than the 17.4-percent return from cheek-tagged

3/ The unexpectedly poor results shown by the streamer-tagged fish led to the marking of 50 additional fish, near the posterior base of the dorsal fin, (25 with No. 34 nylon thread and 25 with No. 46) in May 1956. Five months later, however, only 36 percent of the fish still carried tags (44 percent of the fish with tags attached with No. 34 thread and 28 percent with No. 46 thread). These results agree fairly well with those of the first trial, with an average loss of about three-quarters of the tags in the first half year.

TABLE 2.--Percentages of tagged native lake trout recovered after release in the Apostle Island region of Lake Superior in June, 1952-1954

Type of tag, and year	Number of fish marked	Year after tagging[1] 1	2	3	4	5	Total (June 1958)
Petersen							
1952	98	30.6	4.1	4.1	3.0	1.0	42.9
1953	100	29.0	4.0	6.0	---	---[2]	39.0
1954	100	31.0	4.0	1.0	---	---[2]	36.0
Total	298	30.2	4.0	3.7	1.0	0.3	39.3
Cheek							
1952	93	17.2	3.2	1.1	---	---	21.5
1953	89	7.9	7.9	1.1	---	---[2]	16.9
1954	100	9.0	4.0	1.0	---	---[2]	14.0
Total	282	11.3	5.0	1.1	---	---	17.4
Jaw							
1952	100	11.0	4.0	5.0	2.0	---	22.0
1953	100	17.0	4.0	2.0	---	---[2]	23.0
1954	201	11.9	1.5	---	---	---[2]	13.4
Total	401	13.0	2.7	1.7	0.5	---	18.0
Streamer							
1952	200	17.5	6.0	1.5	---	---	25.0
1953	100	24.0	12.0	1.0	---	---[2]	37.0
1954	98	27.6	2.0	---	---	---[2]	29.6
Total	398	21.6	6.5	1.0	---	---	29.1
Grand total	1,379	16.9	4.6	1.8	0.4	0.1	25.7

[1] First year extends from the date of tagging to the first anniversary of the tagging date; subsequent years extend to successive anniversaries. No recoveries were reported during the sixth year after tagging, for fish marked in 1952.

[2] Recoveries could not have been expected because the experiment was not in progress.

native fish. The Petersen tag yielded a total return of 39.3 percent in Lake Superior, or more than double the return from cheek tags, whereas results with these two tags were nearly identical in the rearing pond.

The results for jaw tags in the raceway were not directly comparable with results in Lake Superior, because both upper- and lower-jaw tags were used in the Lake Superior experiments. In 1952 and 1953 fish less than legal size (17.0 inches, total length) were tagged with No. 3 strap tags on the lower jaw, whereas larger fish were marked on the upper jaw with this tag. In 1954 each type was used on both legal and undersized fish. Returns during the 3 years after this marking totaled 15.0 percent from 100 fish tagged on the upper jaw and 11.9 percent from 101 marked on the lower jaw. In this limited test, the difference in the rate of return of tags attached to the upper jaw as compared to the lower jaw was not significant--in contrast to the rearing-pond experiment, in which all of the upper-jaw tags had been lost within 7 months, whereas 91 percent of the lower-jaw tags remained in place at the end of 1 year.

TABLE 3.--A comparison of length, weight, and coefficient of condition of lake trout held in rearing ponds for 1 year after marking

[Standard errors in parentheses]

Mark, and date	Number of fish	Average length (inches)	Average weight (pounds)	Average coefficient of condition[1]
Petersen tag				
October 1955	100	8.6	0.18	28.7
May 1956	96	9.8	0.29	30.5
October 1956	86	11.7	0.52	31.6
Difference[2]	-14	3.1	0.34	2.9
		(0.064)	(0.011)	(0.232)
Cheek tag				
October 1955	100	8.5	0.18	28.6
May 1956	93	9.6	0.27	29.9
October 1956	[3]85	11.5	0.49	31.8
Difference[2]	-15	3.0	0.31	3.2
		(0.069)	(0.012)	(0.424)
Lower jaw tag				
October 1955	100	8.5	0.19	30.8
May 1956	95	9.8	0.29	30.7
October 1956	91	11.5	0.51	32.4
Difference[2]	-9	3.0	0.32	1.6
		(0.076)	(0.014)	(0.242)
Streamer (No. 34 thread)				
October 1955	100	8.5	0.18	28.7
May 1956	23	9.5	0.25	29.5
Streamer (No. 46 thread)				
October 1955	100	8.5	0.18	28.7
May 1956	15	9.4	0.25	29.1
Adipose fin clip				
October 1955	[4]100	8.3	0.18	31.3
May 1956	[5]91	9.9	0.29	30.0
October 1956	95	12.3	0.59	31.7
Difference[2]	-5	4.0	0.41	0.4
		(0.115)	(0.016)	(0.003)

[1] $C = \frac{W \times 10^5}{L^3}$ where W = weight in pounds and L = total length in inches.

[2] The differences are for the period October 1955 - October 1956. Values for length, weight, and C are average differences for tagged fish (which were individually recognizable); but for fin-clipped fish, differences between means are given.

[3] Two fish were not weighed; average weight and C are based on 83 fish.

[4] Four or more fish apparently were overlooked in May 1956.

[5] Three fish were not weighed; average weight and C are based on 92 fish.

Some tags of each of the 4 types used in the 1952-54 Lake Superior experiments were recovered after extended intervals of time. The longest periods between release and recapture were: Petersen, 4 years 3 months; cheek, 2 years 4 months; jaw, 3 years 3 months; and streamer, 2 years 11 months.

With the exception of upper-jaw tags, the marked disagreement between recovery rates in Lake Superior and survival or tag-retention rates at the rearing station is not believed to result from differences in the size of the fish in the two situations. The high rate of return from Petersen tags in the fishery is unquestionably due to their far greater vulnerability to gill nets, the principal commercial fishing gear for taking lake trout in Lake Superior. Streamer tags are more conspicuous than jaw and cheek tags on lake trout and perhaps were more likely to become entangled in gill nets (although this proclivity was far less than for Petersen tags). The frequent thrashing about of tagged fish in the confinement of the rearing pond may have contributed materially to the loss of streamer tags in the holding experiment. In general, the data suggest that observations of tagged fish in a rearing pond cannot safely be used to predict results in an open-lake environment.

Growth and Condition of Tagged Fish

Differences in the average rate of growth in length and weight among lots of fish tagged with Petersen, cheek, and lower-jaw tags were not significant. Between October 1955 and October 1956, average increases in length ranged only from 3.0 to 3.1 inches and increases in average weight were 0.31 to 0.34 pound (table 3). During the same period, fish with the adipose fin clipped added 4.0 inches in average length and increased 0.41 pound in mean weight. The difference in growth between the three groups of tagged fish (data combined) and the fin-clipped fish was highly significant (lengths: $t = 10.66$; weights: $t = 4.70$).

Although fish from the lots tagged with Petersen, cheek, and lower-jaw tags were equally retarded in growth (about 25 percent) by the marks, the tags did not have an adverse effect on the coefficient of condition (average C values for lots of tagged and fin-clipped fish were within the narrow limits of 31.6 and 32.4 at the end of 1 year). Growth was retarded also among streamer-tagged fish observed from October 1955 to May 1956. These data suggest that the tags have an effect on the fish which might require consideration in the evaluation of the individual performance of brood lake trout marked with these kinds of tags and held at fish-cultural stations.

Literature Cited

Cable, Louella E.
1950. A cheek tag for marking fish, with semi-automatic pliers for application of tag. Jour. du Cons. Internat. Explor. Mer 16: 185-191.

Joeris, Leonard S.
1953. Technique for the application of a streamer-type fish tag. Trans. Amer. Fish. Soc. 82 (1952): 42-47.

Shetter, David S.
1936. The jaw-tag method of marking fish. Pap. Mich. Acad. Sci. Arts, and Let. 21 (1935): 651-653.

1951. The effect of fin removal on fingerling lake trout (Cristivomer namaycush). Trans. Amer. Fish. Soc. 80 (1950): 260-277.

In 1908, temporary labor at a Federal fish hatchery cost $1 a day--a 10-hour day.

VIBRIO INFECTIONS AMONG MARINE AND FRESH-WATER FISH

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IN 1951, B. J. Earp[1] found a vibrio infection among salmon fingerlings being reared in salt water at the Deception Pass Biological Station of the Washington State Department of Fisheries. The disease was characterized by erythema at the base of fins and on the sides of the fish, necrotic areas in the musculature, inflammation of the intestinal tract, and general septicemia. The disease reappeared the next year, killing nearly all of the chum salmon (Oncorhynchus keta) fingerlings, killing about half of the pink salmon (O. gorbuscha) fingerlings, and affecting to a lesser degree the chinook salmon (O. tshawytscha) fingerlings. Also, late in 1952, R. R. Rucker and E. J. Ordal found the same disease at a rainbow trout hatchery of the Washington State Department of Game at Vancouver. The disease caused severe losses there among the rainbow trout (Salmo gairdneri) and among the sea-run form of the same species (called steelhead trout). The disease was manifested by bloody, necrotic areas in the musculature and inflammation of the viscera, similar to furunculosis.

The main object of this paper is to bring vibrio infections of fish to the attention of the American fish-culturist.

Review of Literature

A brief review of the literature is of interest to the hatcheryman because this disease has been known for more than 2 centuries in Europe--where the etiologic agent is recognized as a pathogen of marine and fresh-water fish--but has not been found extensively in America (Rucker, Earp, and Ordal, 1954). The early interest in the etiologic agent was initiated because of its similarity to Vibrio comma, the organism that causes cholera in humans. The investigations have shown the causative agents of the fish disease to be different from V. comma and not pathogenic for warm-blooded animals.

The earliest paper that I reviewed on a vibrio infection in fish was by Canestrini (1893), who first described the etiologic agent of the predominant disease of eels in Italy as Bacillus anguillarum (= Vibrio anguillarum). The disease was characterized by hemorrhagic areas in the skin, reddening of the fins, and sometimes the presence of cutaneous ulcers. The etiologic agent was shown to be pathogenic for eels, sticklebacks, goldfish, frogs, and newts, but not for rabbits, guinea pigs, or mice.

Bergman (1912) found that in September and October 1910, about 10 percent of the codfish caught off the south coast of Sweden between Ystad and Trälleborg had a vibrio infection. Characteristically the eyes were infected. The etiologic agent was like V. anguillarum and was pathogenic for the eel and the roach but was considered nonpathogenic for the carp, rabbit, guinea pig, or white mouse.

[1] Personal communication.

It is difficult to find definite information on the severity of infections, as most references deal primarily with the etiologic agent, but Bruun and Heiberg (1932) gave some information. They found that the red disease of eels in Danish waters caused losses of as much as 30 percent, varying in different years and in different localities. A little more information on the marine disease was presented by Bückmann (1952). In examining 117 plaice naturally infected and held in an aquarium, he found that 49 percent were certainly infected, 29 percent were probably infected, and the other 22 percent did not have the vibrio infection--it is possible that these survived the infection without showing signs of the disease. He also stated that one might assume that 70 percent of all these plaice in the aquarium did die or would have died from this disease.

The etiologic agent of a fresh-water form of this disease was described by David (1927) as V. piscium. He studied an epidemic in a commercial fish pond near Vienna in 1924. The pond was restocked with 2,000 yearling carp when the first epidemic was over; after an occurrence of the infection among this group of fish, only 15 to 20 of them survived until the pond was drained. During the next season, 1,500 two-summer carp were placed in the pond and a heavy mortality appeared after 6 weeks. The virulence seemed to be less, but all carp died within 6 months. He mentioned another occurrence in which pike were sold to 3 commercial fish farms. The disease did not appear in the originating farm but broke out in the others 8 to 10 days after the introduction of the new fish. The loss was attributed to weakening of the fish from transportation.

Aaser (1925), working on the vibrio disease of pike in Norway, did not find it in perch, roach, gwynead, burbot, or trout. He showed that it was experimentally pathogenic for the pike, whereas it did not attack the roach and perch. Also, it was not pathogenic for mice, guinea pigs, rabbits, or pigeons. He showed that the vibrio survived freezing for more than 6 months but was killed at 50° C. (122° F.) in 5 minutes.

Schäperclaus (1954) discussed the vibrio infections at length, but for the purpose of this review it is sufficient to note that--in contrast to the disease of pike in fresh water--the marine form is of longer duration and slower in development.

Discussion

R. E. Pacha and E. J. Ordal[2/] showed by serological methods that the original strains of the vibrio isolated from pink and chinook salmon fingerlings in salt water and from rainbow trout in fresh water--all in the State of Washington--were identical. Also, Pacha showed that strains of vibrios subsequently isolated from several groups of salmon fingerlings, from adult herring (Clupea pallasii), and from a case of eye infection in cod (Gadus macrocephalus) were serologically related but not identical to the first isolates nor to each other.

Vibrio infections can be controlled in hatcheries by any of the standard sulfonamide therapeutic measures commonly used for fish (Hoshina, Kunimine, and Takahashi, 1957). Some reported pseudomonad infections responded to sulfonamide therapy, although generally the pseudomonads are resistant to this treatment. Of course, one immediately wonders about the correct identification of the etiologic agent. Along this line of thought, Shewan, Hodgkiss, and Liston (1954) reported that vibrios and pseudomonads can be differentiated by their response to antibiotics and a vibriostatic agent. They wrote: "Indeed, many of the types from fish, provisionally classified as Pseudomonas spp., now appear by this test to be Vibrios."

Routinely, the vibrios are differentiated from the pseudomonads by the presence of curved forms and the presence of involution forms which develop in culture. This might be subject to question, as J. Liston[2/] has found that some vibrios produce straight forms and some pseudomonads produce curved forms and in a

[2/] Personal communication.

sea-water medium may even produce involution forms. This is a problem for the bacteriologists.

The frequently occurring vibrio infection at the marine station could enter through the water supply. It is possible that the infection at the trout hatchery was introduced through the use of frozen ocean fish as food. We know that vibrio infections often kill herring being held for live bait. Also, we know that mass mortalities have occurred in the Alaska herring populations. Pilchards (Foerster 1941) and herring (Tester 1942) have undergone mass mortalities near Vancouver Island, British Columbia, with pathology which might be considered similar to the vibrio infections. In the European literature one often sees recommendations that fish products used as food in hatcheries should first be cooked. Perhaps we should take greater heed of this suggestion--at least be fully aware of the disease potential in fresh or frozen fish products.

The diseases we recognize at this time in marine fish that are used for feeding hatchery fish are rather widespread. Infections caused by Vibrio spp. are probably greater than we are aware of at present. Corynebacterium sp., which causes kidney disease or white-boil disease, is known from the Pacific coast across the United States to the Atlantic coast. Mycobacterium spp., which cause fish tuberculosis, have been recognized on both the eastern and the western coast of the United States. Both of these diseases are not too uncommon in adult salmon, which are frequently incorporated in the diets of young fish. There is a filterable agent found in the adult sockeye salmon, and possibly one in the adult chinook salmon, that on occasion causes severe losses among fingerlings. Ichthyosporidium hoferi, the cause of the herring disease in Maine and well-recognized as a fish pathogen from marine fish in Europe, as well as myxosporidian infections, is found in hatchery fish. Therefore, vibrio infections take their place with these other known fish diseases, which are carried in the food or water as a "sword of Damocles" to the hatcheryman.

Summary

Vibrio infections of fish, which appear similar to furunculosis, can be spread by contaminated water or by infected fish from the salt-water or fresh-water environment. The disease responds to sulfonamide therapy.

Literature Cited

Aaser, C. S.
1925. Gjeddepesten i 1923. Norsk Vet. Tidsskr. 37: 1-14, 33-42, 74-86, 99-121, 142-157, 180-186, 219-223, 277-295, 322-330, 347-351, 396-400.

Bergman, A. M.
1912. Eine ansteckende Augenkrankheit, Keratomalacie, bei Dorschen an der Südküste Schwedens. Zbl. Bakt. Abt. I. Orig. 62: 200-212.

Bruun, A. Fr., and B. Heiberg
1932. The "red disease" of the eel in Danish waters. Medd. Komm. Havundersøg. Kbh. Ser. Fiskeri 9 (6): 1-19.

Bückmann, A.
1952. Infektionen mit Glugea stephani und mit Vibrio anguillarum bei Schollen (Pleuronectes platessa L.) Kurze Mitt. aus d. Fischereibiolog. Abt. des Max-Planck-Inst. f. Meeresbiologie in Wilhelmshaven (1): 1-7.

Canestrini, G.
1893. La malattia dominante delle anguille. Atti Ist. veneto Ser. 7, 4: 809-814.

David, H.
1927. Ueber eine durch choleraähnliche Vibrionen hervorgerufene Fischseuche. Zbl. Bakt. Abt. I. Orig. 102 (1/3): 46-60.

Foerster, R. E.
1941. The mortality of young pilchards, 1941. Fish. Res. Bd. Canada, Prog. Rept. Pac. Coast Sta. 48: 3-8.

Hoshina, T., I. Kunimine, and T. Takahashi
1957. Preliminary studies on control of the vibrio disease of rainbow trout. Bull. Jap. Soc. Sci. Fish. 23 (5): 241-244.

Rucker, R. R., B. J. Earp, and E. J. Ordal
1954. Infectious diseases of Pacific salmon. Trans. Amer. Fish. Soc. 83 (1953): 297-312.

Schäperclaus, W.
1954. Fischkrankheiten. 3d ed., 708 pp. Akademie Verlag. Berlin.

Shewan, J. M., W. Hodgkiss, and J. Liston
1954. A method for the rapid differentiation of certain non-pathogenic, asporogenous bacilli. Nature 173 (4396): 208-209.

Tester, A. L.
1942. Herring mortality along the south-east coast of Vancouver Island. Fish. Res. Bd. Canada, Prog. Rept. Pac. Coast Sta. 52: 11-15.

FIN MARKS OF UNDETERMINED ORIGIN

At Bonneville Dam on the lower Columbia River, the U. S. Fish and Wildlife Service uses four inclined-plane traps in the fingerling bypasses to get information about the time and composition of migrations and to observe the passage of marked fish from marking studies above the dam.

From February 29 through April 5, 1956, the traps caught 2,549 seaward-migrating silver salmon. Of these, 609 had pectoral fins cropped close to their bodies: 270 had the left pectoral missing, 265 had the right pectoral missing, and 74 had both pectorals missing. No deformities were noticed on any fins but the pectorals. Several biologists agreed that the marks appeared to be valid, but the presence of this relatively great percentage of marked silver salmon at Bonneville was incongruous with available lists of marks authorized for use on Columbia River fish.

The release of 487,000 yearling silver salmon from two hatcheries above Bonneville Dam on February 17, 1956, seemed at first to have no connection with these fish. Study of the probable rate of travel of silver fingerlings down the river and the dates of recoveries at the dam, however, indicated that these marked and unmarked silver salmon were probably from these hatcheries. The day before release, samples had been preserved at both hatcheries. Of ten preserved at one hatchery, one fish had both pectoral fins eroded to about one-third normal size and nine fish had normal fins. Of the ten preserved at the other hatchery, one fish had one pectoral of about half normal size and another fish had one pectoral completely missing. The three mutilated pectorals appeared to have been caused by erosion; the pectoral fin that was completely missing clearly resembled a "fin-clip." In other respects the sample fish resembled those taken at the dam; therefore, it seemed reasonable to assume that the marked fish were part of the two hatchery releases and were victims of accidental mutilation, not products of a marking experiment.

As there is no record of fin rot or mutilation in the hatchery background of these silver salmon, the origin of this mutilation remains undetermined.

--CLARK S. THOMPSON and BEN R. PULLIAM, Bureau of Commercial Fisheries, Seattle, Washington.

JAR CULTURE OF TROUT EGGS

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JAR CULTURE OF WARM-WATER FISH EGGS has been practiced for many years. The quantity of eggs incubated is legendary. With the change of times and thinking, many of these units have been abandoned and the jars stored on remote shelves. This system was very efficient; jars could be arranged so that vertical space in the hatchery building could be utilized and one man could care for a large quantity of eggs in a limited space.

It was felt that, with modifications, this system could be adapted to the culture of trout eggs with resulting increased efficiency and savings in trout culture. Therefore, a battery of jars was constructed and tested (figure 1).

Results to the present time have been satisfactory. Not only has the jar culture proved adequate for incubating trout eggs for use in production, but the jars have also supplied many units of controlled, identical environments for research purposes. In connection with the latter, the unit has proved useful for chemical tests such as the screening of fungicides, for selective breeding where strains need to be held separately, and for holding small numbers of fry and fingerlings separate to test chemicals or starter feeds. It also presents an opportunity for individual treatment in a controlled environment that may be required for other types of research problems with trout eggs or fry.

Description of Equipment

The first consideration was a source of water which would be free of foreign materials that might clog the battery at some points. To eliminate algae and other comparatively large materials, a 55-gallon drum was installed at the head of the water supply (figure 1). The water was piped from the supply trough into the bottom of the drum. About 8 inches from the bottom on the inside of the drum, an 8-mesh screen was placed and was supported by concrete blocks. On top of the screen, roofing gravel was placed to within 7 inches of the overflow. This unit was effective as a filter for larger materials. Undoubtedly, a combination of better materials would eliminate foreign matter down to the size of silt particles. An outlet plug was placed at the bottom of the drum, below the screen, in order to drain the drum and back-flush it.

The supply trough and outlet trough (9.25 inches wide, 9.25 inches deep, and 12.5 feet long) were fabricated from 12-gauge sheet steel (figure 2). A simple unit can be constructed using 2-inch pipe for the inlet supply and ordinary eaves spouting as an outlet trough. The T (figure 2) was made of 0.75-inch galvanized pipe. This has been reduced to 0.25 inch in order to connect the glass tube that enters the jar. The top of the T is open. This aids in eliminating air bubbles or other excess gases. Also, it allows an opening to treat eggs or fry or to feed fry. This T-arrangement can be reduced to smaller sizes throughout as long as the diameter of the piping is greater than the final tube that supplies the jar. If the T is not greater in size, it will act with a Venturi effect and suck air into the jar.

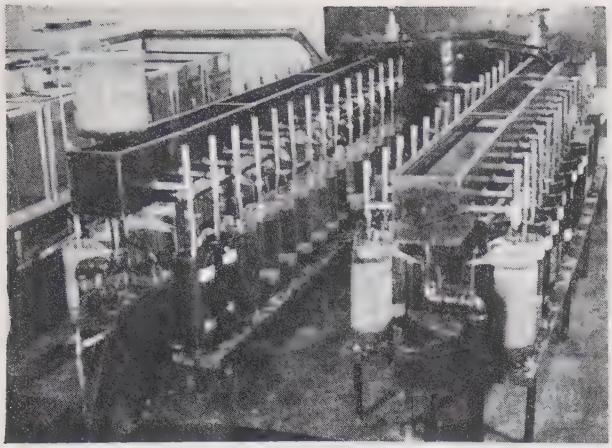


FIGURE 1.-- Two trout egg incubators. The water filter is in the background, between them.

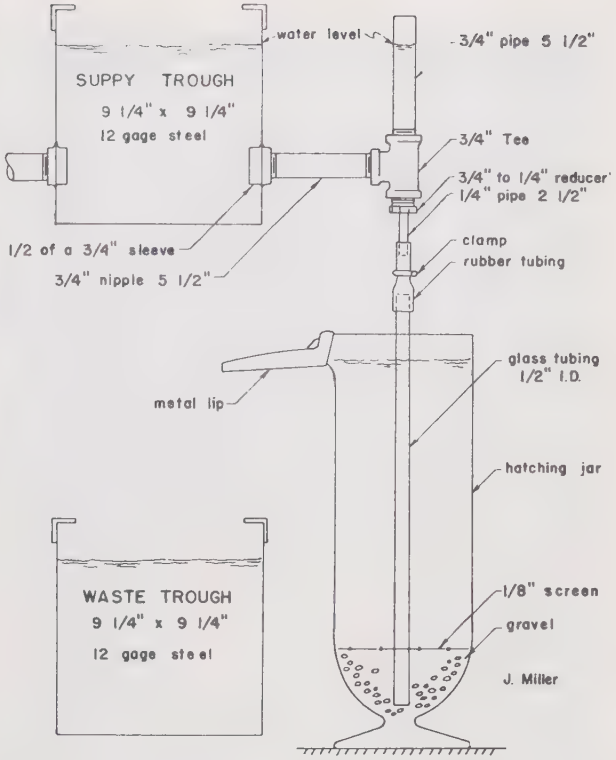


FIGURE 2.-- Details of the egg incubation unit and water supply system.

The jars used were of 6-quart 23-ounce capacity. These were placed on supporting planks on 8.5-inch centers. The inlet tube was placed to within 0.5 inch of the bottom in the center of the jar. Then 1 quart of roofing gravel was added. This gravel allows a dispersion of water so that the eggs do not roll. There was some smothering of fry when the screen was used without gravel. On top of the gravel, an 8 x 8 mesh, painted, galvanized-wire cloth was placed to prevent the hatching fry from burrowing into the gravel. The eggs were placed on top of the screen. Sixteen jars were placed on a side, and 32 in the battery. The width of the entire battery was 32 inches.

Operation

The even dispersion of the water flow makes it possible to place the eggs into the jar to water-harden immediately after fertilization. No washing is necessary, but large materials such as excrement should be removed. Four quarts of eggs (after swelling) seems to be the best workable quantity to use in this size of jar, but as many as 5.5 quarts were eyed successfully in a jar. The flow of water was adjusted to about 2 quarts per minute per jar, and the air bubbles were eliminated. It was found that the bung spigot used previously in jar culture shut off when adjusted to such a low flow. The T, with an adjustable metal clamp on the rubber tubing connecting the T and the inlet tube, was found to be the most satisfactory arrangement for adjusting the flow. Probably a better method would be to have the inlet tube just large enough to carry the flow desired. The eggs will incubate with less flow, but clogging due to airlocks or foreign material may occur.

Batteries at this station were operated with both flush and constant-flow siphon treatment of fungicides (figure 3). Results were comparable to those obtained with eggs treated in standard troughs. It is felt that the treatment normally effective in hatchery troughs works at least as well as in the jars. Observations show that the chemical is more evenly dispersed in the jars; hence it appears even more efficient.

If the eggs are allowed to hatch in the jars, the dead eggs can be removed by placing the contents of the jar (eggs and

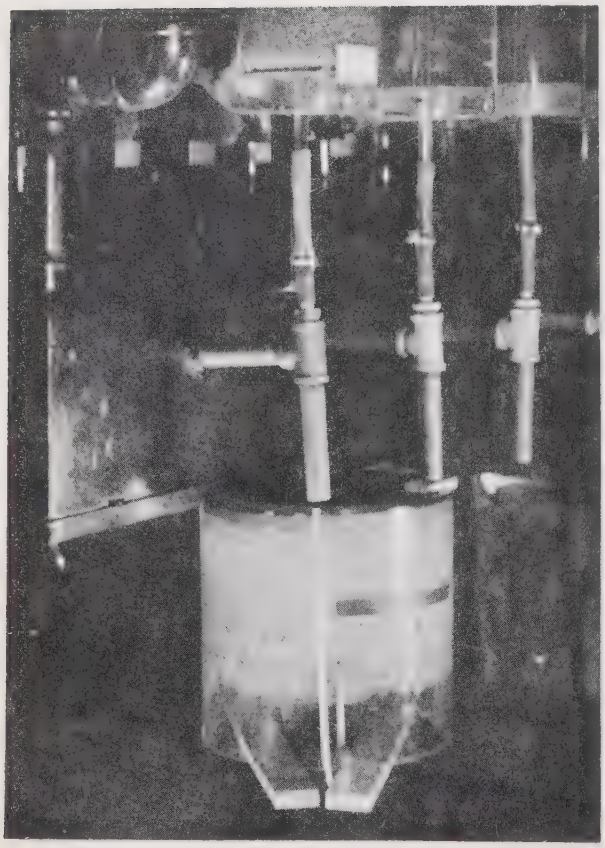


FIGURE 3.-- T-arrangement used to connect supply trough and jar. Constant flow siphon on top drains into jars through the T.

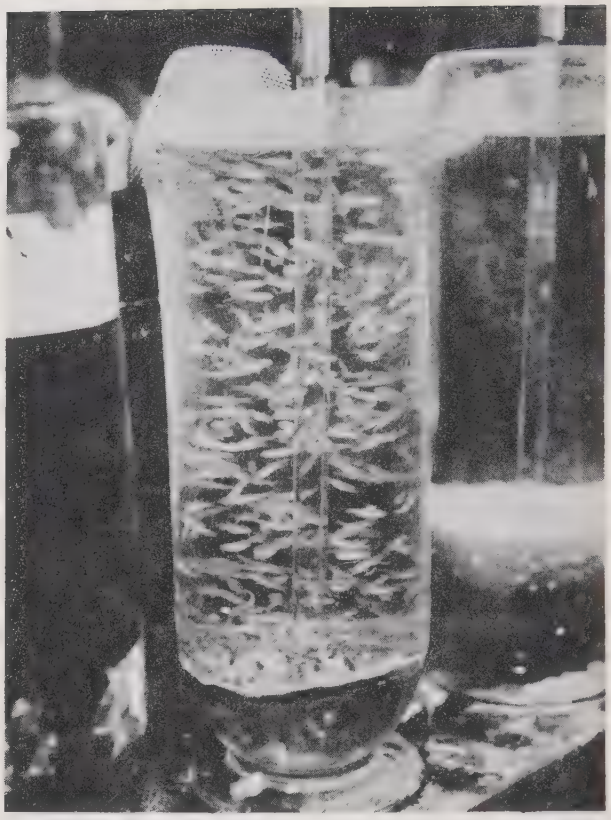


FIGURE 4.-- Experimental rainbow trout in jars.

(Photographs by Johnny Nicklas, Pennsylvania Fish Commission)

fry can be siphoned from the jar) on a tray with a 2 x 7 mesh screen. The fry go through the screen and are caught in a wire basket underneath. The dead eggs are left on the tray and can be thrown out without any picking. If the fry are left in the jar without cleaning, or if the cleaned fry are replaced in the jar, rainbow and brown trout sac fry will slowly swim out, whereas brook trout sac fry have a tendency to swim downward and stay in the jar. Caution should be used in treating the sac fry with a fungicide because some concentrations of fungicides are toxic or have an adverse effect.

Each of the units shown in figure 1, when filled to capacity, will incubate 128 quarts of eggs--about 1,000,000 eggs from 3-year-old brown trout, 1,500,000 eggs from 3-year-old rainbow trout, or 2,000,000 eggs from 2-year-old brook trout. Flush treatment of these eggs in 1 unit requires about 15 minutes. The unit will operate on a total water flow of 16 gallons per minute.

The jars can also serve to hold small lots of fish for comparative treatment or feeding. The jar shown in figure 4 contains 350 rainbow trout. They were placed in the jar when they started to feed and were still thriving and growing after a 3-month period.

Conclusions

The jar-culture method is efficient and economical for incubating large quantities of trout eggs, as no pickoff is necessary

and little labor is involved in the treatment of the eggs. The space required is about equivalent to that of the standard double hatching trough in Pennsylvania, in which ordinarily only 15 quarts of eggs are incubated.

The jar method is well adapted to use in research with eggs or fry, as the environment can be held constant and the water dispersion is uniform. The principles described here have functioned well at the Benner Spring Fish Research Station and on a pilot model scale at several of our production hatcheries.

Experimental lots of rainbow trout eggs were incubated successfully in this type of unit at the State Fish Hatchery at Hackettstown, New Jersey, and at the Greenwalk Commercial Hatchery at Bangor, Pennsylvania.

Acknowledgments

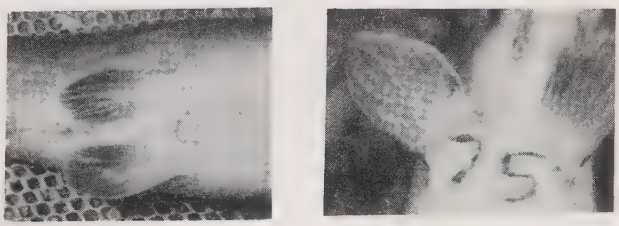
The author is indebted to the staff of the Benner Spring Fish Research Station for their aid and advice--particularly to Raymond McCreary, superintendent; Jack Miller, fishery biologist; Jack Reddecliff, fishery biologist; Dixon Waite, mechanic; T. F. O'Hara, chief engineer; A. D. Bradford, pathologist; and J. E. Wright, consultant geneticist.

TATTOOING AS A METHOD OF MARKING CHANNEL CATFISH

In order to identify individual fish from year to year, numbers were tattooed on channel catfish brood stock at the U. S. Fish-Cultural Station at Tishomingo, Oklahoma. In preliminary experiments, numbers were tattooed on the caudal peduncle, belly, and pelvic girdle. The dark areas did not give enough contrast with black ink. The white skin on the ventral surface provided the contrast; but when the tattoo was put on the belly, the needle did not penetrate deeply enough to carry the ink into the tissues for a permanent mark. The firmer support in the region of the pelvic girdle allowed the needle to penetrate, and tattoos properly applied here have been identifiable after a year. All numbers should be put on the skin over the girdle.

Fish may be anesthetized or held immobile by an assistant. Before the tattoo is applied, the mucus must be removed from the pelvic area with a cloth. The number should be traced several times with a pricking rather than a writing motion. Penetration of the ink can be determined by wiping the area with a cloth. The number should be uniformly black and very dense.

If the catfish are kept in captivity in a trough, infections may occur and some erosion of tissues will result. If fish are to be held thus, the occurrence of infection can be minimized by injecting 10,000 units of penicillin into the fish or by swabbing with a disinfectant the region where the tattoo is applied.



Left. A tattoo (29) after 1 year. Note the clarity of the 2 on the pelvic girdle--and the fading of the 9 on the belly.

Right. A 6-week-old tattoo properly applied on the skin over the pelvic girdle.

Equipment for the tattooing consisted of: a combination electric tattoo machine, with a broad-line needle; a foot switch; a switchboard, with rheostat; four 6-volt dry batteries; and a 1/2-ounce bottle of Pelican concentrated black ink.

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A PRELIMINARY REPORT ON THE USE OF NITROFURAN COMPOUNDS FOR FURUNCULOSIS OF TROUT, WITH SPECIAL EMPHASIS ON FUROXONE

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CHEMISTS are constantly preparing new synthetic, organic chemical compounds. Many times these compounds are a result of challenges to the chemist. Other times they are prepared with the hope that they will be of a particular value. Whatever the stimulus for preparing these materials, only additional research will yield information to indicate beneficial uses for them. Such is the case of the group of substituted nitrofuran chemical compounds which were used in this study. Research has found uses for many nitrofuran compounds as chemotherapeutic agents for diseases of warm-blooded animals. Fishery research personnel should also examine them for their therapeutic value for diseases of fish.

Nitrofuran compounds are usually golden yellow; they are almost insoluble in water; they have only slight odor or taste; they usually show their greatest systemic therapeutic effect when they are given orally. Therapeutic concentrations can be established in the body fluids and can be produced in large volume at a relatively low cost.

This research was undertaken in order to determine whether a nitrofuran compound which would be useful in treating furunculosis was available. Sulfonamide-resistant strains of Aeromonas salmonicida are becoming more prevalent, and fishery personnel are turning to the more expensive antibiotics for treatment of the disease (Snieszko and Bullock 1957). Past experience indicates that bacterial strains which are resistant to antibiotics as well will develop. The usual finding in nitrofuran research has indicated that bacteria do not develop resistant strains so readily as they do when antibiotics or sulfonamide drugs are used.

Material, Methods, and Results

Six nitrofuran compounds were used for this research. These compounds included Furoxone (N-(5-nitro-2-furfurylidene-3-amino-2-oxazolidone, also known as furazolidone); Furacin (5-nitro-2-furaldehyde semicarbazone); Furadantin (N-(5-nitro-2-furfurylidene)-1-aminohydantoin); NF-67 (5-nitro-2-furaldehyde-2-(2-hydroxyethyl)-semicarbazone, also known as Furadroxyl); NF-23 (ethyl 3-(5-nitro-2-furyl) acrylate); and NF-86 (5-nitro-2-furonitrile).[1/]

A strain of Aeromonas salmonicida obtained from outbreaks of furunculosis in four Wyoming fish-cultural stations was used in all tests. This organism has shown no resistance to sulfamethazine nor to antibiotics. It will produce typical

This is a contribution from the Federal Aid in Fish Restoration Act Project FW-3-R, Wyoming.

[1/] All compounds donated for the study by Eaton Laboratories, Norwich, New York.

lesions of furunculosis in brook trout, brown trout, and cutthroat trout.

The organism was subjected to in vitro testing with six nitrofuran compounds. The standard cylinder cup-plate method was used. Four of these drugs were dissolved in water to standard amounts, but Furoxone and NF-23 were dissolved in 10 percent ethyl alcohol. Dilutions were made to permit the required amounts of drug to be present in 0.1-milliliter portions of solution. Sterile cups were placed on seeded media in petri plates. Measured amounts (0.1, 0.2, or 0.3 milliliter) of the desired drug solution were then placed in the cups. The plates were incubated at 20° C. The zone of inhibition was measured at 24- and 48-hour intervals.

Results of the in vitro tests are shown in table 1. Furoxone yielded the largest zone of inhibition. The least amount of Furoxone (15 micrograms) gave a wider zone of inhibition than the largest amount (180 micrograms) of the next most active drug, NF-86.

Toxicity tests of Furoxone were made on brook trout. Weighed amounts of Furoxone were placed in No. 5 gelatin capsules. A small glass balling gun was used to place the capsule directly in the stomach of each fish each day. Control fish were given an empty gelatin capsule each day in the same manner. Fish receiving daily capsule doses were held in individual running-water aquaria. Doses were continued for 15 days. There was no mortality that could not be attributed to other causes (1 fish died 3 days after the last dose because of injury in handling, and 1 control fish died on the 12th day because the water was shut off).

After the experiment the 2 fish that had received 500 milligrams per kilogram per day for 15 days were killed, preserved, and sectioned for pathological study. These fish showed normal gills. The liver was normal but had an increased number of melanin particles, possibly because of the light conditions surrounding the fish during the experiment. The kidney appeared to have slight edema in the tubules; but the glomeruli, Bowman's capsules, and hemopoietic tissue appeared normal. The spleen showed normal architecture, with increased melanin. The stomach and intestinal tract showed some drug retention but no pathology. Table 2 gives information on this experiment.

The in vivo activity of Furoxone on Aeromonas salmonicida was tested in a 20-gallon running-water aquarium. The top of the aquarium was sealed with a wooden lid to prevent spread of the disease to other fish in the laboratory. A small trapdoor was made in the lid to permit tending of the fish. An air line and air stone carrying filtered air and two 75-watt thermostatically controlled heaters were installed in the aquarium before the lid was sealed. Sixteen brook trout weighing a total of 282 grams and thirty-six cutthroat trout weighing a total of 282 grams were placed in the aquarium. The heaters and air were turned off to give the aquarium a temperature of 45° F. Twenty-four-hour cultures of Aeromonas

TABLE 1.--Plate inhibition of Aeromonas salmonicida by six nitrofuran compounds

NF-23		Furoxone		NF-86		NF-67		Furacin		Furadantin	
µg. [1]	mm. [2]	µg.	mm.	µg.	mm.	µg.	mm.	µg.	mm.	µg.	mm.
15	0	15	30	15	10	15	0	15	0	15	s1
30	0	30	33	30	13	30	11	30	s1	30	11
45	0	60	37	60	17	60	16	60	12	60	12
		90	39	120	21	120	19	120	13	120	14
				180	24	180	21	180	17	180	16

[1] Micrograms of actual drug (governed by the solubility of the drug).

[2] Diameter of the zone of inhibition in millimeters.

salmonicida were looped from solid media and added to ground beef liver. The freshly inoculated liver was fed at the rate of 2.4 percent of body weight per day for 40 days. At the end of the inoculation period the heaters and air were turned on. The temperature was maintained at 58° F. Fish began to die in 2 days. Aeromonas salmonicida was cultured from the kidney of all dead fish. After the mortality had continued for 6 days, Furoxone was added to the diet at the rate of 100 milligrams per kilogram of fish per day. The mortality continued for 3 days after initiation of the treatment with this drug. The drug was fed at this level for 14 days, after which time it was withdrawn. There was no recurrence of the disease for 1 month, after which time 4 brook trout (260 grams) of susceptible stock were placed in the aquarium. The aquarium was maintained at 62° to 65° F. There was no occurrence of the disease in either the original group of fish or the last group of fish for 6 more weeks, after which the experiment was completed.

Discussion

The in vitro trials of the six nitrofuran compounds used in these studies indicated that Furoxone showed the most promise as a therapeutic agent for furunculosis. The other drugs which should be tested in vivo are NF-86, NF-67, and possibly Furacin and Furadantin, although these compounds are not so promising as Furoxone. NF-23 apparently has no activity on Aeromonas salmonicida.

The toxicity level of Furoxone indicated that this drug could be used as a therapeutic; even 500 milligrams per kilogram per day used for 15 successive days showed no pathological effects on brook trout. Apparently fish can absorb only a small amount of the drug into the body fluids from the alimentary tract, as large amounts are excreted in the feces. One brook trout was given 1,000 milligrams per kilogram per day for 10 days in another experiment. The only noticeable effect was the increased excretion of the drug. The insolubility of the drug will limit the systemic level in the body of the fish.

The in vivo experiment with Furoxone indicated that the drug has definite value as a therapeutic agent for furunculosis. Mortality was stopped more quickly than is usually possible with sulfamethazine, terramycin, or aureomycin. Fish that showed developing furuncles before the

TABLE 2.--Toxicity of Furoxone to brook trout

Tank No.	Number of fish	Weight in grams	Dose rate, mg./kg./day	Milligrams of drug per day	Number of days	Remarks
1	1	62.0	Control	0.0	12	Died on 12th day. Water off.
2	1	68.0	Control	.0	15	Remained alive and in good health.
3	1	50.0	100	5.0	15	Remained alive and in good health.
4	1	76.0	100	7.6	15	Remained alive and in good health.
5	1	84.0	250	21.0	15	Died 3 days after last dose. Injured in handling.
6	1	68.0	250	17.0	15	Remained alive and in good health.
7	1	77.0	500	38.5	15	Killed for pathological examination.
8	1	86.0	500	43.0	15	Killed for pathological examination.

first dose of Furoxone was given, were observed to improve and to heal without mortality. The fact that there was no recurrence of the disease is extremely encouraging and indicates that the disease organism has been removed from the alimentary tract as well as from the body tissues.

Furoxone has a number of characteristics that make it ideally suited as a therapeutic agent for fish diseases. It is soluble in water to the extent of 40 milligrams per liter, it is stable to heat and cold, and it is stable at pH ranges from 4 to 9. The LD_{50} to white mice has been found to be over 4,000 milligrams per kilogram (Rogers et al. 1956). The drug is a yellow crystalline powder which can be incorporated into feed. Because of its low toxicity, it is ideal for a free choice drug to use in mass fish-disease control.

The reader must keep in mind that this report is a preliminary one. It can be safely said that Furoxone shows very little toxicity to brook trout, that at 100 milligrams per kilogram per day it will cure furunculosis without recurrence of the disease when the fish are in glass-lined aquariums. What will happen when the drug is used in cement or dirt-lined ponds or raceways must be determined. Work is continuing at the Wyoming Game and Fish Research Laboratory to determine the toxicity of Furoxone to other species of trout and the most economical level of the drug. Furoxone appears to be an ideal therapeutic agent for furunculosis because of the wide margin between the therapeutic level and the toxic level. Other side effects should be studied. Transient sterility has been noted in white mice after the administration of high levels of nitrofuran compounds (Nelson et al. 1954).

The remaining five nitrofuran compounds used for the in vitro studies have been reserved until all necessary data are collected for the use of Furoxone in the control of furunculosis.

Results of this study indicate that fishery research personnel should examine many of the newly produced drugs and antibiotics for use in the control of fish disease. There are, no doubt, many useful compounds available today. A purpose and a method of using them must be determined through research.

Acknowledgments

The writer wishes to thank the Eaton Laboratories of Norwich, New York, and especially Dr. George E. Short of that organization, for the excellent bibliography and reference material supplied and for the drugs used in this study.

Literature Cited

Nelson, W. O., E. Steinberger, and A. Boccabella
1954. Recovery of spermatogenesis in rats treated with nitrofurans. Anat. Rec. 118: 333-334.

Rogers, G. S., G. B. Belloff, M. F. Paul, J. A. Yurchenco, and G. Gever
1956. Furazolidone, a new antimicrobial nitrofuran. Antibiotics and Chemotherapy 6: 231-242.

Snieszko, S. F., and G. L. Bullock
1957. Treatment of sulfonamide-resistant furunculosis in trout and determination of drug sensitivity. U. S. D. I., Fish and Wildl. Serv., Fish. Bull. 125 (57): 555-564.

Studies at the Eastern Fish Nutrition Laboratory of the Bureau of Sport Fisheries and Wildlife at Cortland, New York, indicate that niacin, choline, inositol, and folic acid are essential factors in the growth of lake trout.

DIVIDENDS FROM RESEARCH

MULLET RESEARCH IN FLORIDA

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The Marine Laboratory of the University of Miami was founded in 1943 in an area where little work had been done by marine biologists. Since the founding of the laboratory a considerable part of the research effort has had to be devoted to cataloguing the plants and animals and measuring the environmental conditions. Such information must be obtained before marine research can be applied in the service of the fisheries. Despite the lack of background work and the consequent necessity to collect basic facts, some studies have already paid off as money in the pockets of fishermen by providing better recreational areas for anglers or by preserving natural areas essential to the protection of important species of fish.

Some obvious dividends from research at The Marine Laboratory have come from studies in the field of fish technology. These studies have contributed to the fishing industry's increasing awareness of the need for quality control and for new packs and products.

In most cases, dividends from research in biological problems are less obvious but no less important than those resulting from technological research. One such biological investigation and its benefits to the fishing industry are described here.

Florida's most important food fish is the black mullet. In 1957 the landings of this species amounted to more than 32 million pounds, with a value of about $2 million. Prior to the middle of 1957, a closed season on commercial fishing for mullet had been imposed each year from December 10 until January 20 of the following year. This regulation had been devised in order to protect the stocks during what was thought to be the spawning period.

At the request of the Florida State Board of Conservation, The Marine Laboratory of the University of Miami had conducted investigations on the black mullet since 1948. These studies embraced many phases of the life history in different parts of the State. It became apparent that the stipulated closed season would result in only a partial protection of the spawning stocks because spawning in the northwestern area was partly over by the beginning of the closed season. By inference from other fisheries, the merit of protecting spawning stocks was questioned. It was suggested to the legislators that ample spawning fish were probably present every year to maintain the stocks, and that the closed season would therefore result only in a decrease in landings with no resultant good to the fishery. These investigations also failed to show a decline in the abundance or availability of mullet as a result of excessive fishing and hence the need for regulations restricting fishing at this time. Acting on these results and conclusions, the legislators withdrew the closed-season regulations in 1957.

Unrestricted fishing has been permitted for only 1 year to date, but already benefits to the fishermen are apparent. The landings between April 1956 and March 1957 (during which time the 40-day closed season was operative) totaled about 29 million pounds. During the following 12 months, after the removal of the closed season, the landings were about 32 million pounds. The difference cannot be

attributed entirely to the removal of the closed season. However, during the 12-month period from April 1956 to March 1957, 14.7 percent of the mullet were taken during December and January and fishing was permitted during only part of these months. During the period from April 1957, to March 1958, with unrestricted fishing, the combined December and January landings amounted to 19.2 percent of the total production. The difference, 4.5 percentage points, is probably due largely to the removal of the fishing restrictions. This difference, at the 1957 level of total landings, amounts to almost 1.5 million pounds of fish, or about $85,000. Thus the biological investigations of the Florida mullet have yielded a dividend in the form of increased catches and money for the fishermen.

YOU, TOO, CAN NOW HATCH CLAMS

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The Greeks couldn't do it, the Romans couldn't do it, and the Chinese couldn't do it. Even the predominating majority of present-day biologists were skeptical of the idea that such mollusks as the hard-shell clam (Venus mercenaria) or the oyster (Crassostrea virginica) could be artificially cultivated, in large numbers and as a matter of routine, from the egg to a size large enough to be planted as seed. However, this has been accomplished in the last few years by the U. S. Fish and Wildlife Service's biologists at Milford.

During the past winter, with the small personnel and limited laboratory space available, we managed to grow millions of seed clams. This was accomplished by our biologists, who spent sometimes tedious, sometimes exciting, but always long hours behind microscopes to understand the principles which govern the early development and growth of bivalves.

To begin with, we developed a method of conditioning and inducing spawning of mollusks in winter and--as it now stands--any time during the year, thus offering biologists working in northern waters the opportunity to have ample material, regardless of the season.

Secondly, our biologists had to learn a great deal about what are known as the ecological and physiological requirements of larvae. These studies covered many things, such as salinity, hydrogen ion concentration, and quantity and quality of food organisms. Not only the ranges of each, but also the optima had to be determined. The boys with the microscopes kept working long hours, forgetting about weekends and, usually, vacations.

No sooner were the first steps successfully taken than a new list of problems arose. For example, in the early stages of our work with larvae, as well as with juvenile mollusks, we found that they were subject to many diseases, to attack by parasites, and to smothering by competitors, which rivaled the small bivalves for space, food, and oxygen. However, we soon learned how to control several diseases--some caused by fungus and some by bacteria. We are also fighting successfully many predators and competitors. To achieve this, we had to resort to basic studies. Again, it was the "guy behind the microscope" who found the solution.

We know now that we are winning the battle and that our research of the last 10 years is already paying dividends, which become greater and greater as time goes by. This is not an unbased assumption. Only last spring we distributed approximately 1 million seed clams to biologists and practical shellfish men for experimental planting. We are growing hybrids with desirable qualities. The first commercial clam hatchery in the world, planned to produce 300 million seed clams a year, is under construction in Virginia. It will be managed by a young man who was trained at our laboratory in the methods of raising clams from the unfertilized egg to chowder size. You can do the same if you want to learn. The "guys behind the microscopes" will teach you.

HOMING, MOVEMENTS, AND MORTALITY OF WILD CUTTHROAT TROUT (*SALMO CLARKI* RICHARDSON) SPAWNED ARTIFICIALLY

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STRAWBERRY RESERVOIR, UTAH, is an 8,000-acre artificial lake at the elevation of 7,550 feet. It supports a population of cutthroat trout that are trapped by Utah Fish and Game personnel as they enter the two main tributaries to spawn. The fish are held until ripe and then are spawned artificially. From 1 to 6 million cutthroat trout eggs are taken annually. Data for these spawners during the 1956 run are as follows: average age, 3.5 years; average length, 411 millimeters; average weight, 1,123 grams; and average condition factor, 1.35.

While personnel were sorting the daily runs, it became evident that the ratio of spent to green spawners increased as the season progressed. If spawners repeatedly re-entered the trap after being spawned artificially and returned to the reservoir, then the total number of spawners entering the trap would be much larger than the actual population of spawners running the stream. A marking project was begun to determine number of re-entries and number taken in the fishery, and to study general movement, homing, and mortality.

Studies pertaining to homing (the compulsion of an individual to return to a specific locality) in the family Salmonidae have been restricted mainly to anadromous species. Adfluvial species have received less attention.

Although the following data do not deal with the known return of mature fish to the parent stream, the information does shed some light on the homing instinct of an adfluvial species.

Methods

During the 1956 and 1957 spawning runs, 2,068 and 1,983 spawners, respectively, were marked by the removal of a combination of fins. A different combination was used at each trap. The fish were marked immediately after being spawned artificially. Marked spawners were then released into the reservoir at a distance of 1 to 4 miles from the traps. During and after the marking program all tributaries were observed frequently; marked spawners were counted, and dead marked spawners were removed from the stream. The small size of the tributaries was ideal for the observation of marked spawners. The percentage of spawners returning to the tributaries was high; part of this was due to the fact that the same fish returned to the trap more than once. Each time a marked spawner returned to the trap, the fish was counted and again returned to the reservoir. Some fish may have made three or four appearances. By marking spawners it was soon found that a large percentage would traverse the reservoir and re-enter the tributaries. For instance, on June 6, 1956, 24 hours after release, 79 out of 850 marked spawners came back to the home stream.

The fin-clipping could have caused mortality, but this was probably negligible. Shetter (1951), studying the effect of fin removal on fingerling lake trout, concluded that the difference in mortality which occurred among marked and unmarked fingerlings was not significant.

The possibility that fin-clipping may hinder the movements of spawners is also doubtful. Radcliffe (1950) showed conclusively that fin removal did not affect the "cruising speed" of goldfish or salmon fry.

Error resulting from regeneration of fins was impossible during the first summer, for none of the fin clips showed signs of regeneration by the end of the spawning run. It would be possible to have fin regeneration before the next spawning run, but this should be negligible with complete fin removal. Both Armstrong (1949) and Shetter (1951) observed that approximately 95 percent of marked fingerlings had one-half or less fin regeneration. Clipping fins of yearling brown trout, Heacox (1943) found that complete regeneration was so rare that the clipping of the ventral fins might be considered an effective method of marking brown trout for future identification. Slater (1949) found that the larger the fish the less fin regeneration. No marked spawner was observed the next year with more than one-half fin regeneration.

Indian Creek Trap

Indian Creek enters the south end of the reservoir and flows down a long spillway which is impassable to fish. In order for cutthroat trout to enter Indian Creek, they must ascend a fish ladder entering the stream above the spillway.

During the 1956 spawning run, 918 spawners were marked immediately after artificial spawning. They were then released in the reservoir 1 to 2 miles away. Of this total, 418 returns were observed within 30 days, with most of the returns coming 1 to 3 days after release. Three hundred and forty-four ascended the fish ladder and returned to the same stream; of these, 44 were found dead, 14 of this group being found dead in the reservoir. Sixty were observed in tributaries other than Indian Creek, where only 1 was dead. Eighty-three percent of the returns went back to the home stream, and 14 percent migrated into other tributaries. This clearly shows the strong homing instinct, as the locations of release into the reservoir gave spawners an equal opportunity to enter other tributaries. The high percentage of returns also indicates that the spawning urge is not completely quelled by artificial spawning. Both male and female spawners, artificially spent, re-entered the tributaries and prepared and defended a redd.

The return of only 31 marked spawners the second year indicates the high mortality suffered from hazards that accompany spawning. Out of the 918 marked spawners, 4 percent were caught during the 1956 fishing season, 2 percent returned the following year to spawn, and less than 1 percent was taken by fishermen during the 1957 fishing season. This leaves 93 percent unaccounted for, which is probably close to the actual mortality.

Clyde Creek Trap

The Clyde Creek trap is 2 miles upstream from the northern end of the reservoir, approximately 7 miles from the Indian Creek trap.

During the 1956 spawning run, 1,150 spawners were marked at the Clyde Creek trap. Seven hundred and twelve returns were observed in the tributaries after being released in the reservoir at a distance of 1 to 4 miles. Six hundred and forty-four returned to the home stream, and 141 of these were found dead. Forty-eight spawners returned to streams other than the home tributary; of these, 32 were found dead. One spawner marked at the Clyde Creek trap entered the Indian Creek trap. Only 7.5 percent entered tributaries other than the home stream. This again shows the strong homing instinct. High mortality must have occurred, as a very low percentage returned to the trap in 1957 and only 10 percent of the 1,150 were picked up by fishermen during the 1956 fishing season. This leaves almost 90 percent unaccounted for, and this percentage probably represents the mortality.

Marked Spawners, 1957

Spawners were marked again during the 1957 season: 969 at the Indian Creek

trap and 1,014 at the Clyde Creek trap. Only 2 from the Indian Creek trap and 6 from the Clyde Creek trap were checked during the 1957 creel census; again, as in the 1956 fishing season, only a small percentage of spawners was harvested.

Streeper Creek Mortality

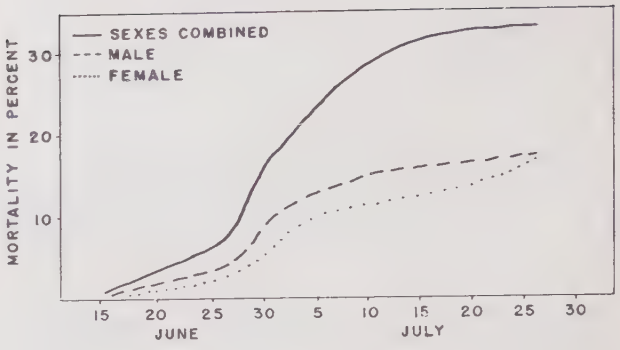
During the 1957 season, 123 male and 129 female spawners were collected from the Indian Creek trap. They were fin-clipped and released in Streeper Creek for a natural reproduction study. More than 30 percent of the spawners released were taken from the stream dead. (See figure.) The majority had completed spawning.

Almost 100 percent of the dead spawners were diseased. Injuries, lack of feeding, too much physical exertion, and other hazards that accompany spawning weaken spawners, resulting in susceptibility to diseases. Males and females died at the same rate, showing that the spawning was as hard on the male as on the female. Approximately 40 percent returned downstream alive; 33 percent died; the remaining 27 percent were not accounted for, but probably died. The returning spawners, many of them diseased, probably suffered further mortality after they reached the reservoir.

Conclusion

Cutthroat trout spawners with a strong drive to complete the spawning act were observed to travel the length of the 6-mile reservoir. Many marked spawners traveled 7 miles upstream, where migration was stopped by beaver dams. The high percentage of returns to the home stream gave supporting evidence of a homing instinct of cutthroat trout in an adfluvial environment.

The foregoing data indicate that mortality of both naturally and artificially spawned wild cutthroat trout is very high. Once it has completed spawning, a cutthroat trout in this type of environment is of little value to the future replenishment and should be made available to the creel.



Observed mortality of 252 marked spawners released in Streeper Creek during the 1957 spawning season.

Literature Cited

Armstrong, G. C.
1949. Mortality, rate of growth, and fin regeneration of marked and unmarked lake trout fingerlings at the Provincial Fish Hatchery, Port Arthur, Ontario. Trans. Amer. Fish. Soc. 77 (1947): 129-131.

Heacox, Cecil
1943. Fin regeneration in brown trout. Trans. Amer. Fish. Soc. 72 (1942): 231-232.

Radcliffe, R. W.
1950. The effect of fin-clipping on the cruising speed of goldfish and coho salmon fry. Jour. Fish. Res. Bd. Canada 8 (2): 67-73.

Shetter, D. S.
1951. The effect of fin removal on fingerling lake trout (Cristivomer namaycush). Trans. Am. Fish. Soc. 80 (1950): 260-277.

Slater, D. W.
1949. Re-formation of excised fins of king salmon fingerlings and its effects on recognition of marked adults. Trans. Amer. Fish. Soc. 77 (1947): 132-140.

MODIFICATIONS ON AN ALTERNATE-POLARITY ELECTRODE

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TO SAMPLE FISH POPULATIONS in Connecticut's coastal streams, a shocker employing the alternate-polarity electrode described by Petty (1955) was selected for use. Haskell (1954) plotted the electrical field for this type of electrode, along with others used by New York workers, and found the alternate-polarity non-grounded type very effective. This type of electrode also proved effective in the waters of this State. When this electrode was first used, however, it was believed that certain modifications of the basic design would materially increase the safety, durability, and effectiveness of the apparatus.

Safety Switch

The dangers inherent in the operation of a 230-volt alternating-current shocker are apparent. One of the first problems to solve was the construction of a switch that would be safer than the open-knife switch used in the original design. The new switch should not only be safe for the operator, but also enable him to have instantaneous control of the current as a safety measure for the other crew members. It was believed that some type of single-action push-button switch would serve the purpose. A 250-volt, 6-ampere, single-action, push-button switch which would carry the current was obtained. However, this switch was open at the terminals and required some type of housing. A little modification of a transparent plastic box provided this housing. It is believed that sheet plexiglass can be used effectively to construct this switch box.

It was found that the switch mounted on the handle of the electrode could not be held in the "on" position by thumb or hand pressure for any length of time because of excessive spring tension on the button. A supplementary lever was devised so that the operator could hold the switch "on" as he grasped the handle of the electrode. With the switch box bolted to the handle, a clamp was fashioned of 3/4-inch aluminum strap to fit around the handle, just forward of the switch box. This clamp was constructed so as to receive the flattened end of a 3/8- by 14-inch aluminum rod. The rod was bolted securely to the clamp so that it swiveled freely. The rod was bent so as to come just in contact with the switch button. Another short bend in the rod placed it in proper position so that the operator could easily grasp both the rod and the handle, thus holding the switch in the "on" position. In order to maintain the rod in proper position over the handle, a bracket was made by using a short piece of 3/4-inch aluminum strap. The strap was bent at an angle of 90°, and an elongated 1/2-inch hole was bored in one end. The bracket was bolted to the handle just forward of the hand-hold, and the rod was placed through the elongated hole. (See figure 1.)

This handle gave the operator a fatigue-free method of holding the switch "on," yet enabled him to shut off the apparatus by

This is a contribution of Federal Aid in Fish and Wildlife Restoration Project F-15-R, Connecticut.

FIGURE 1.--Electrode handle with mounted safety switch.

simply releasing his hand-hold. This switch has been used for approximately 2 years and has proved very effective.

It should be pointed out that the switch box was not waterproof and, therefore, it was necessary to determine whether this would be dangerous to an operator who might chance to fall in the water when the switch was in the "off" position. Voltmeter tests of the switch while it was submerged showed that there was no current passing through the switch when it was "off." Also, there was very little leakage into the water around the switch, even in the "on" position. It is believed that this switch could be used effectively on almost any type of shocking apparatus.

Following is a list of materials used in the construction of this switch:

1	Single-action switch, rated 6 amperes, 250 volts; 12 amperes, 125 volts
1	Plastic (lucite) box, approximately 1" x 1" x 2"; or plexiglass, 1/8"
14 inches	Aluminum or steel rod, 3/4"
12 inches	Aluminum strap, 1/8" x 3/4"; or brass strap, 1/16" x 3/4"
1	Rubber-covered female plug
	Assorted nuts and bolts

Aluminum Electrode

It was found during the first year of use that the alternate-polarity electrode, as originally designed (Petty 1955), often required repair and replacement of parts after relatively heavy usage. It appeared advantageous, therefore, to construct a more durable electrode. It was believed that aluminum tubing would solve this problem. Aluminum tubing, 3/4-inch in outside diameter and 36 inches long, was substituted for the wooden dowel and copper shielding cable. The 2 wire leads were run directly through each section of the electrode. A small lip was cut in one end of each section of aluminum pipe, and the leads were connected to the tubing with short lengths of wire soldered to the leads and bolted to the turned-down lips with aluminum nuts and bolts (figure 2). By this manner of attachment, the entire surface of the aluminum tube transmitted the electrical current.

Crutch tips were put over the ends of each section to insulate one from another and protect the electrical connection. The wire leads were run through holes drilled in the ends of the crutch tips. Enough slack was left so that there was no tension on the wire. The sections were connected by plastic clothesline passed through the crutch tips and tubing. If repair became necessary, the clothesline could be removed, the crutch tip pulled off, and the electrical connection exposed. Holes were drilled in the tubing to allow it to sink, as each section was virtually watertight. (See figure 3.)

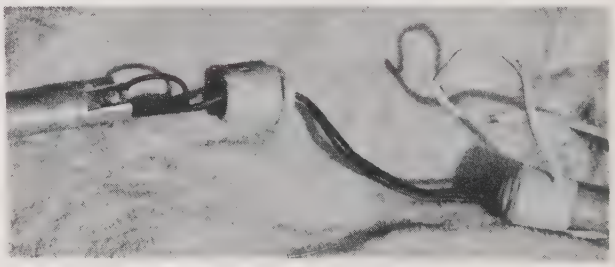

FIGURE 2.--Electrical connection between sections of the electrode.

FIGURE 3.--Plastic - clothesline connection between sections, each with a crutch-tip insulator.

To avoid excessive wear and breakage, an 18-inch length of aluminum tubing (outside diameter, 1-1/4 inches) was added to the end of each handle and the wire leads were placed inside this tubing. A large crutch tip on the end of the aluminum tubing gave the operator a more or less slip-proof support in fast water. Also, the tubing provided a more satisfactory means of attaching the handles to the electrode. An eyebolt with a swivel-base snap was fastened to the end of the tubing, and this snap was fastened to a loop of plastic clothesline at each end of the electrode (figure 4).

While this type of electrode was being used in various-sized streams, it was noted that there would be advantages to having a unit that was readily adaptable to stream widths. In larger streams, a 24-foot (8-section) electrode was found to be satisfactory; in smaller streams, a 12-foot (4-section) electrode was more appropriate. In order to facilitate the use of these different lengths, two 12-foot electrodes which could be joined for use in larger streams were constructed. A third handle was attached by means of a snap swivel at the center of this 24-foot electrode to facilitate the upstream movement of the crew and add support. Inexpensive rubber-covered connectors for use in wiring trailer lights to automobile electrical systems were used to connect the two sections, which were held together by placing the plastic clothesline loops of both sections through the snap of the center, or third, handle. This resulted in a 24-foot electrode which could be disconnected rapidly at the center to make a 12-foot section (figure 5). This arrangement eliminated the need for two switches when two different lengths of electrodes were necessary. During the past season's field work, a third 12-foot section was added in the same way for use in larger streams and appeared to function with equal efficiency.

Another very short electrode of the same design was constructed for use in small headwater streams. This one was only 6 feet in length and was formed of four 18-inch sections of the aluminum tubing. This short electrode was also found to be quite effective.

One other small addition to the apparatus consisted of a small neon test light attached to the end of the circuit so that the operator could tell whether the apparatus was functioning. Although this test light told nothing of the efficiency, it did indicate whether there was a break in the

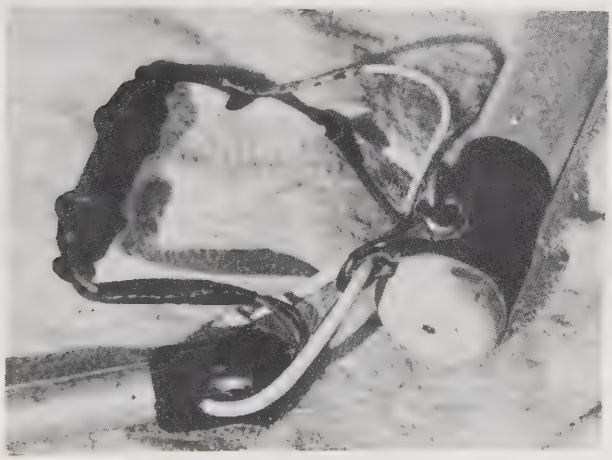

FIGURE 4.--Connection between handle and electrode.

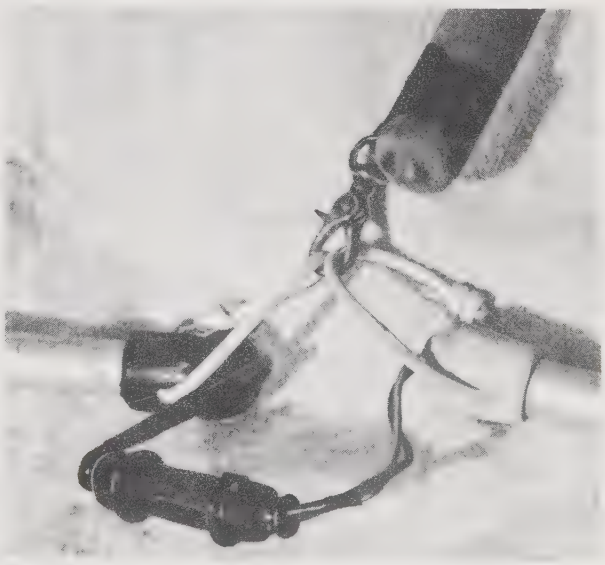

FIGURE 5.--Two 12-foot electrodes shown with rubber-covered trailer electrical connectors. Also shown, the method of attachment of central support handle.

circuit. The light was taped to the end of the handle and connected to the electrode in the same manner as the switch handle.

In addition to the durability of the aluminum-tubing electrode and the ability to lengthen or shorten it quickly as stream conditions warranted, operators seemed to think that greater efficiency was achieved. A voltmeter was used to compare the fields of the two electrodes. The results are shown in the following table:

COMPARISON OF THE FIELDS OF THE ALUMINUM AND SHIELDING-CABLE ELECTRODES

Distance from submerged electrode	Voltage[1/]	
	Shielding cable	Aluminum
	(volts)	(volts)
Contact	218	218
6 inches	65	80
12 inches	25	50
18 inches	10	30
24 inches	2	15

[1/] Readings taken when the water temperature was 57° F.; the pH, 6.7.

No increase in mortality was observed with the use of the aluminum electrode and its increased voltage. In one test, more than 100 trout of various sizes collected with this electrode were held for 7 days and no mortality or ill effects were noted.

Following is a list of materials necessary to construct the entire 8-section electrode, less the switch:

3	Closet pole, 6' x 1", for handles
2	Aluminum tubing, 18" x 1-1/4" outside diameter
8	Aluminum tubing, 36" x 3/4" outside diameter
10 feet	Plastic clothesline
16	Crutch tips, 3/4"
2	Crutch tips, 1-1/4"
3	Snaps with swivel base
3	Eyebolts, 1-1/2"
3	Rubber-covered trailer electrical connectors
8	Aluminum bolts, 1/8" x 3/8", with nuts
85 feet	Rubber-covered stranded copper wire, #18
1	Neon test light
1 roll	Electrical tape

Summary

Modification of an alternate-polarity electrode of the type described by Petty (1955) included a safer "on - off" switch. A single - action, 250 - volt, 6 - ampere, push-button switch was housed in plastic and mounted on the handle of the electrode. A lever was fashioned and hinged to the handle in such a way that the lever could be grasped with the handle to depress the button and complete the circuit. In emergencies the circuit could be broken instantaneously by relaxing the lever. When the switch was in the "off" position and immersed in water, no measurable voltage passed across the poles of the switch.

The use of connector plugs permitted rapid changes in length of the electrode to suit the size of the stream.

The addition of a neon test light allowed the operator to tell at a glance whether there was a bad connection or a break in the circuit.

The substitution of aluminum tubing for the wooden dowels and braided shielding cable contributed to the durability of the electrode and to the strength of the voltage field.

Literature Cited

Haskell, D. C.
1954. Electrical fields as applied to the operation of electric fish shockers. N. Y. Fish and Game Jour. 1 (2): 130-170.

Petty, A. C.
1955. An alternate - polarity electrode. N. Y. Fish and Game Jour. 2 (1): 114-119.

MECHANICAL DRY-FEED DISPENSERS

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THE ADVANTAGES OF FEEDING DRY PELLET-TYPE FEEDS in trout hatcheries are well known to hatchery operators. It has been shown that success in using dry feeds depends on a proved diet and on feeding technique. One advantage sometimes overlooked in using dry feeds is the possibility of employing labor-saving devices. Two devices that improve the feeding technique and save labor have recently been developed at a California hatchery. These are the dry-feed dispenser and the pellet blower.

The dry-feed dispenser for feeding small fish in troughs and nursery tanks consists of a slightly modified aluminum valve funnel of the type designed for and usually employed in restaurants to fill individual cream cups of 1-ounce or less capacity.

A valve funnel of either 1- or 2-quart capacity can be obtained at any hotel supply house. Such a valve funnel can easily be modified for fish-feeding purposes by removing the spout at the bottom and enlarging the holes in the bottom screen sufficiently to permit the passage of dry feeds. A small inverted cone, 2 inches in greatest diameter and 1.5 inches deep, is fastened to the lower end of the control rod and acts as a shutoff valve and as a spreader for the feed. The valve funnel is filled with dry feed and held over the hatchery trough. As the person doing the feeding walks the length of the trough, he depresses the release button on the valve funnel, allowing the feed to fall on the surface of the water. With a small amount of practice, a man can learn to gauge quite accurately the amount of feed being dispensed; and by maintaining the proper distance between the dispenser and the water surface, he can scatter the feed in such a way that much of it will float for a period (sometimes as long as 20 minutes) before it settles into the water. The dry-feed dispenser is a definite improvement in feeding technique and reduces considerably the time previously required for feeding fine feeds.

Using modified valve funnels to dispense dry feed to fingerlings in hatchery troughs. Food put on the water surface in this manner will float for a considerable length of time.

A pellet blower that has been developed for feeding pellets to fish in ponds has many advantages. The pellet blower is carried on a regular pickup or flatbed

truck and consists of 2 bins (each with a capacity of about 750 pounds) mounted over a manifold system (4 inches in diameter) attached to the discharge side of a turbo-compressor with a capacity of 1,120 cubic feet of air per minute at 4-ounce pressure at 3,450 revolutions per minute. The compressor is driven by a 3-horsepower gasoline engine.

Loading bagged fish-food pellets into the blower bins. The manifold with flexible end piece permits control of pellet pattern on pond surface. Note gasoline engine mounted over V-belt-driven turbo-compressor.

The rate at which the pellets are admitted into the manifold is regulated by a sliding control gate at the bottom of each bin and controlled by the truck driver from inside the truck cab. Each bin is equipped with a plexiglas window that can be seen by looking through the rear window of the cab. The bin window is calibrated in increments of 10 pounds, and this enables the driver to determine with a reasonable degree of accuracy the amount of pellets being fed. The bins are filled with pellets of the size to be fed. A different size can be put in each bin if necessary.

The blower is placed in operation by starting the gas engine, and the truck is then driven alongside the pond. When the driver approaches the point where feeding is to commence, he merely pulls the control to the bin from which feed is to be taken. The truck is driven the length of the pond at a rate of about 1.5 miles per hour. The amount of pellets fed can be regulated both by the rate at which they are admitted (through the control valve) to the manifold and by the speed at which the truck is driven.

The pellet blower places the pellets on the pond surface in a well-scattered and uniform oval pattern about 10 feet by 20 feet.

Advantages of the pellet blower are even distribution of pellets, less handling of food, and reduction in time required for feeding.

Three ACTH-free fractions of chum salmon pituitaries which were prepared, pelleted in combination with cholesterol, and injected into 3 lots of 90 adult blueback salmon at the Salmon-Cultural Laboratory of the Bureau of Sport Fisheries and Wildlife at Entiat, Washington, apparently had no measurable effect on the acceleration of sexual maturation.

A new strigeoid trematode metacercaria, probably a species of Mesophorodiplostomum has been found in fallfish, creek chubs, common shiners, and cutlips minnow. The worm has been reared to adulthood in baby chicks, but nothing more is known of its life cycle.

A MODIFIED FYKE NET FOR THE LIVE CAPTURE OF SEAWARD-MIGRATING SALMON

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Bureau of Commercial Fisheries
Seattle, Washington

EVERY BIOLOGIST WORKING WITH AN ANADROMOUS SPECIES OF FISH is eventually faced with the problem of capturing the seaward migrants. He may be interested in obtaining samples to determine the timing and duration, the size and age composition, or the magnitude of the migration.

The problem of capturing the downstream migrants has been solved by the use of various devices ranging from complicated weirs and traps to the simple fyke net. Many projects require traps which are inexpensive, easily portable, and simple to operate. The common fyke net meets most of these requirements but has the disadvantages of invariably killing some of the fish captured and rapidly losing efficiency through the collection of debris.

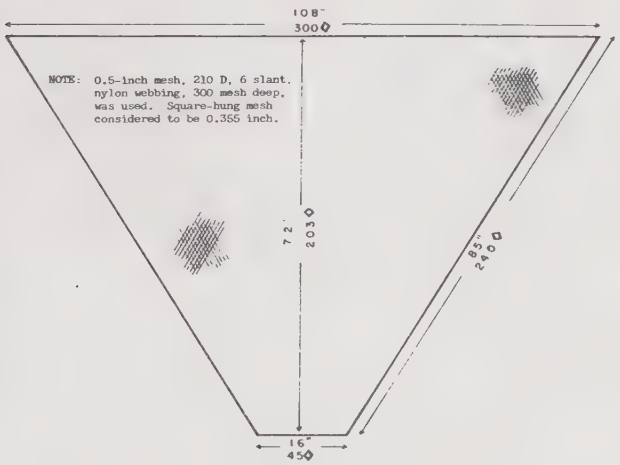

FIGURE 1.--Pattern used to cut the netting.

The modified net described here is capable of capturing migrating salmon fingerlings and holding them alive in good condition. The debris problem is partially relieved because much of the debris is carried into the live-box, where it does little damage and does not foul the webbing of the net.

The cone-shaped net is 6 feet long and extends into the semitorpedo-shaped live-box. The net is constructed of a single piece of 1/2-inch mesh, 210 D, slant 6, nylon webbing and is cut to eliminate the ballooning that is encountered with panel-constructed nets. Figure 1 is a diagram of the pattern used to cut the netting.

The mouth of the net is held open by a 3/4-inch pipe frame 28 inches square, while a 3/8-inch iron ring 15 inches in diameter keeps the center of the net extended (figure 2). The latter ring has 4 line guides welded to it. A 1/4-inch iron ring 5 inches in diameter is fastened 12 inches from the end of the net. This 5-inch ring has tabs welded to it so that it can be fastened to the live-box with a pair of bolts and wing nuts. The net extends 12 inches into the box, and the tunnel exit is kept open by stay lines fastened to each inside corner near the back of the box.

The rib lines are of 3/16-inch nylon and serve to form the bridle, maintain the spacing between the frames, and secure the live-box to the net. They are fastened to the frames by clove hitches to make them adjustable, and to the live-box by snaps and screw eyes.

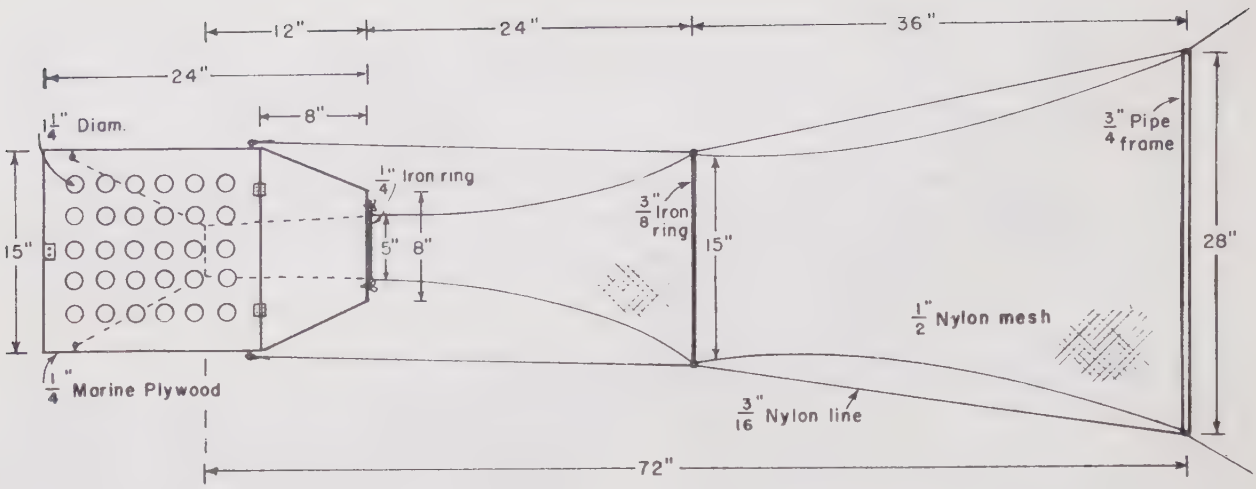

FIGURE 2.--Construction details of the modified fyke net.

The live-box is constructed of 1/4-inch marine plywood to the dimensions shown in figure 2. The box has a hinged lid that allows for the removal of the trapped fish. The opening where the net enters the box is 5 inches in diameter. The torpedo-shaped front portion is solid plywood; the sides, bottom, top, and end are perforated with 1-1/4-inch holes drilled on 2-1/4-inch centers. The top, sides, and bottom have 30 holes each; the end has only 20. This gives an area 8-1/2 times greater than the entrance area where the velocities entering the box may be dissipated. The inside of each perforated section is covered with 6 mesh/inch, 22-gauge hardware cloth.

These nets may be fished in the same situations where a conventional fyke net of comparable size would be used. More than 200 hours of actual fishing has proved the ability of these nets to take fish and maintain them in good condition in velocities ranging from less than 3 feet per second to well over 5 feet per second. They have also proved very durable and easy to handle.

The Snobs Creek trout hatchery of the Victoria Fisheries and Game Department, Australia, uses stainless-steel 15,000-egg baskets, 3 baskets to each 8-foot trough. The steel mesh is rectangular, measuring about 0.25 by 1.5 inches.

For easier handling, this hatchery uses counterbalanced wire-mesh covers to protect from birds and rodents the trout in its circular rearing ponds (capacity, about 17,000 trout each). Each cover is made in two independent semicircular sections.

As part of a Federal Aid in Fish Restoration Program in Maine, four salmon redds in the Fish River chain of lakes were excavated. The eggs were buried under 6 to 9 inches of gravel. The number of egg pits per redd ranged from 1 to 3, with the larger redds containing more egg pits. The number of eggs per redd ranged from 133 to 1,001. Natural fertilization ranged from 94.1 to 98.9 percent.

A PLEXIGLAS CONSTANT-FLOW SIPHON

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AN IMPROVED CONSTANT-FLOW SIPHON has been devised to administer the prophylactic malachite green to incubating eggs for prolonged periods. This apparatus embodies the advantages of the constant-flow administration of malachite green as advocated by Burrows (1949) and avoids most of the difficulties described by Johnson, Adams, and McElrath (1955).

It was believed that some of the problems that have been encountered with the glass-jug constant-flow siphon described by Burrows (1949) could be alleviated by improving the design of the container. The desired container would (1) be made of breakage-resistant materials, (2) be of one-piece construction so that proper adjustment would be possible throughout constant use, (3) have a one-treatment dispensing capacity, (4) have a large fill hole, and (5) be fitted with a bracket to hold the container in proper position during use.

The PAM Company of Portland, Oregon, was consulted. In cooperation with it, there was devised a plexiglas constant-flow siphon which satisfied these requirements.

Description and Operation

Figure 1 shows the plexiglas constant-flow siphon and its parts. The tank and bracket are made of 3/16-inch plexiglas. The air and siphon tubes are made of 1/8-inch acrylic tubing. Inside dimensions of the tank are: 5 inches in length, 5 inches in width, and 5-1/2 inches in height. A 7/8-inch hole is provided at the top of the tank for easy filling and is fitted with a threaded metal plug which has a rubber gasket to insure a good seal. The tube around the fill hole extends 5/8 inch downward into the tank. The tank is fitted with a U-shaped bracket which fits over the side or head end of the hatchery trough.

Figure 2 shows the plexiglas constant-flow siphon in operation. As the first step in operating the apparatus, the tank is filled to the bottom of the fill tube.

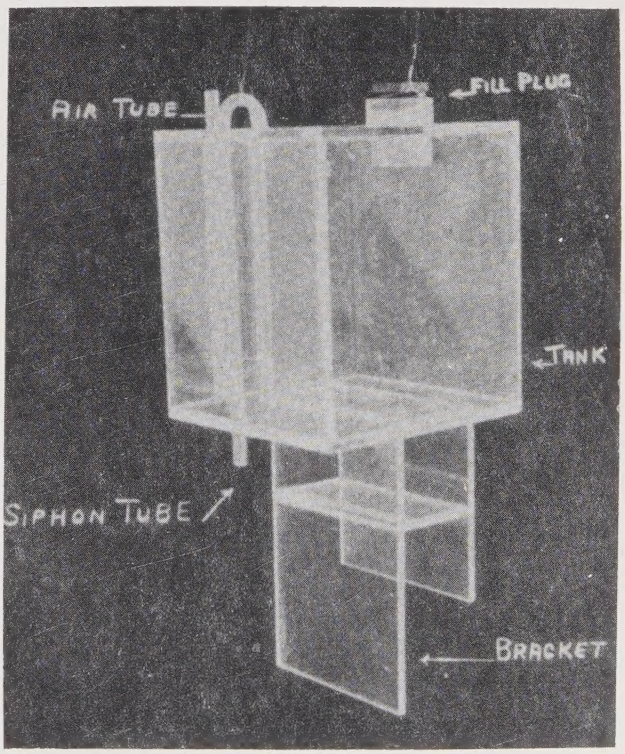

FIGURE 1.--The plexiglas constant-flow siphon with parts labeled.

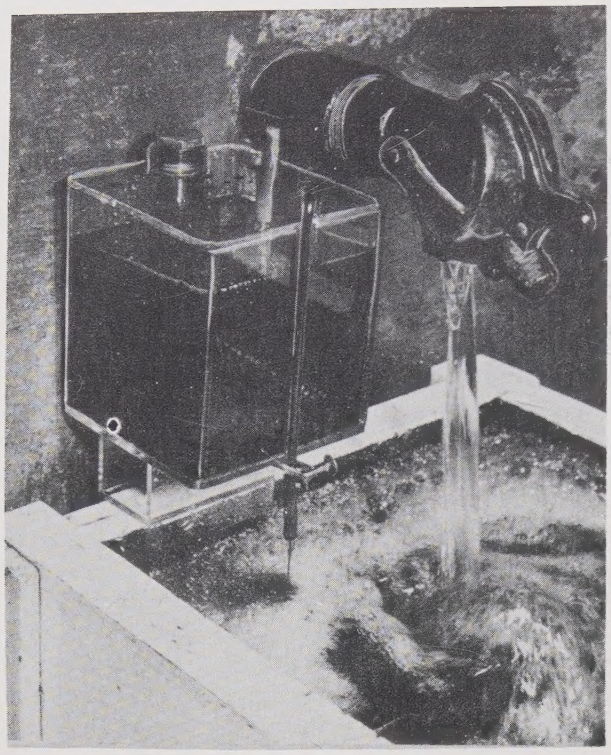

FIGURE 2.--The plexiglas constant-flow siphon in operation.

This provides a dispensing capacity of 1,800 cubic centimeters. The siphon tube is fitted with a piece of amber latex tubing 1-3/4 inches long. A piece of 1-millimeter glass capillary tubing 5/8 inch long is fitted on the end of the latex tubing. The latex tubing is adjusted to allow the end of the capillary tubing to extend 2-1/8 inches below the bottom of the plexiglas tank. The air tube is also fitted with a piece of latex tubing to allow for easy priming of the siphon.

When adjusted as described, the siphon should deliver 30 cubic centimeters per minute of 1:200 stock solution of malachite green.

Discussion

The plexiglas constant-flow siphon is an improvement over the glass-jug constant-flow siphon in the following ways: (1) The plexiglas container and its parts are very resistant to breakage; (2) it is easy to keep in adjustment; (3) it can be left unattended without danger of overtreatment, as the dispensing capacity is just enough for a single 1-hour treatment; (4) the large fill hole makes possible the rapid filling of the tank; (5) the holding bracket keeps the plexiglas constant-flow siphon in proper position during operation.

The plexiglas constant-flow siphon that is shown in figures 1 and 2 is not equipped with a carrying handle. Newer specifications call for a plexiglas handle fastened to the top of the siphon tank.

Literature Cited

Burrows, R. E.
1949. Prophylactic treatment for control of fungus (Saprolegnia parasitica) on salmon eggs. Prog. Fish-Cult. 11 (2): 97-103.

Johnson, H. E., C. D. Adams, and R. J. McElrath
1955. A new method of treating salmon eggs and fry with malachite green. Prog. Fish-Cult. 17 (2): 76-78.

Marine fish quickly take zinc into the body from the digestive tract. Apparently much of it is excreted rather promptly. High blood concentrations of Zn^{65} from feeding of the nuclide to fish were quickly followed by rapid uptake by the kidney, liver, and other internal organs. The Zn^{65} concentrations of these and the blood very quickly declined after reaching this early peak. The liver had the greatest accumulation. A slow and long-continued accumulation took place in bone, integument, and muscle tissues. ---From "Uptake and Accumulation of Radioactive Zinc by Marine Plankton, Fish, and Shellfish" by W. A. Chipman, T. R. Rice, and T. J. Price. U.S.D.I., Fish and Wildl. Serv., Fish. Bull. 135 (58). 1958.

TO CONTRIBUTORS

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A short abstract should be submitted with each manuscript. When an article has appeared in an issue of THE PROGRESSIVE FISH-CULTURIST, the publication data will be added to the abstract and this will then be forwarded to Biological Abstracts and Sport Fishery Abstracts.

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